HYDRO-ELECTRIC INQUIRY COMMISSION

GENERAL REPORT

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

VOLUME I —HISTORY AND DESCRIPTION
VOLUME II—COST, CAPACITY AND OPERATION
VOLUME III—ESTIMATES AND APPROPRIATIONS
VOLUME IV—REASONS FOR INCREASED COST

VOLUME I

JOSEPH H. W. BOWER
SECRETARY

Toronto, Ontario,
November 30,1922.

Hydro-Electric Inquiry Commission,
E. B. Gregory, Esq., Chairman,
Toronto, Ontario.

Re: General Report

The Queenston-Chippawa Power Development

Mr. Chairman and Gentlemen:

In accordance with your instructions, a general report entitled "The Queenston-Chippawa Power Development" has been made in accordance with the general plan approved of by the Commission on January 2nd, 1922.

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

In writing this report it has been found necessary on account of the length of the same to divide the report into four volumes. In making this division the plan followed was to include in each volume matter which could be completely discussed in one volume, thus making each complete in itself. Generally speaking, the discussions have been grouped around questions referred to this Commission in the Letters Patent.

VOLUME I

In addition to answering the specific questions given in the Letters Patent, it has been deemed necessary to give a history and general description of the whole undertaking in order that its various characteristics may be properly understood.

The report, as will be observed from the comments made therein, has been based largely on statements of fact prepared for this Commission by its Consulting Engineer, but wherever new matter of an engineering or constructional character has been introduced, the figures and data used in connection therewith have been carefully checked by our Consulting Engineer and in the main will be included in his report entitled "Discussions".

THE DENNISTON-CHIPPAWA POWER DEVELOPMENT

VOLUME I

Toronto, Ontario,
November 30,1923.

Hydro-Electric Inquiry Commission,
W. D. Gregory, Esq., Chairman,
Toronto, Ontario.

re: General Report

The Queenston-Chippawa Power Development

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In accordance with your instructions, a general report entitled "The Queenston-Chippawa Power Development" has been made in accordance with the general plan approved of by the Commission on January 2nd, 1923.

In writing this report it has been found necessary on account of the length of the discussion to divide the report into four volumes. In making these divisions, the plan followed was to include in each volume matter which could be completely discussed in one volume, thus making each complete in itself. Generally speaking, the discussions have been grouped around questions referred to this Commission in the Letters Patent.

In addition to answering the specific questions given in the Letters Patent, it has been deemed necessary to give a history and general description of the whole undertaking in order that its various characteristics may be properly understood.

The report, as will be observed from the comments made therein, has been based largely on statements of fact prepared for this Commission by its Consulting Engineer, but wherever new matter of an engineering or constructional character has been introduced, the figures and data used in connection therewith have been carefully checked by our Consulting Engineer and in the main will be included in his report entitled "Discussions".

In addition to the data referred to in the preceding paragraph, a complete study has been made of the evidence taken by this Commission at the public hearings held in connection with the Development, together with a study of all letters, documents and other reports that have been prepared in connection therewith. Discussions of a legal nature have been checked and approved of by the legal advisers of this Commission, and our Accountants, Messrs. Price, Waterhouse & Co. have checked any figures or statements used in connection with financial matters.

In preparing the report, the writer has had definitely in mind the necessity of dealing with the various subjects discussed in some detail so that proof of the figures given and the decisions arrived at may be clearly supported and understood. Inclusion of these details has necessarily added to the length of the report, but it is believed, after most careful and extended study, that the report could not be materially shortened.

Yours very truly,

Secretary

JEWS:KM
Encl.

INDEX TO SECRETARY'S REPORT

ON

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

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HISTORY AND DESCRIPTION

[illegible]

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[illegible] 1 - [illegible]

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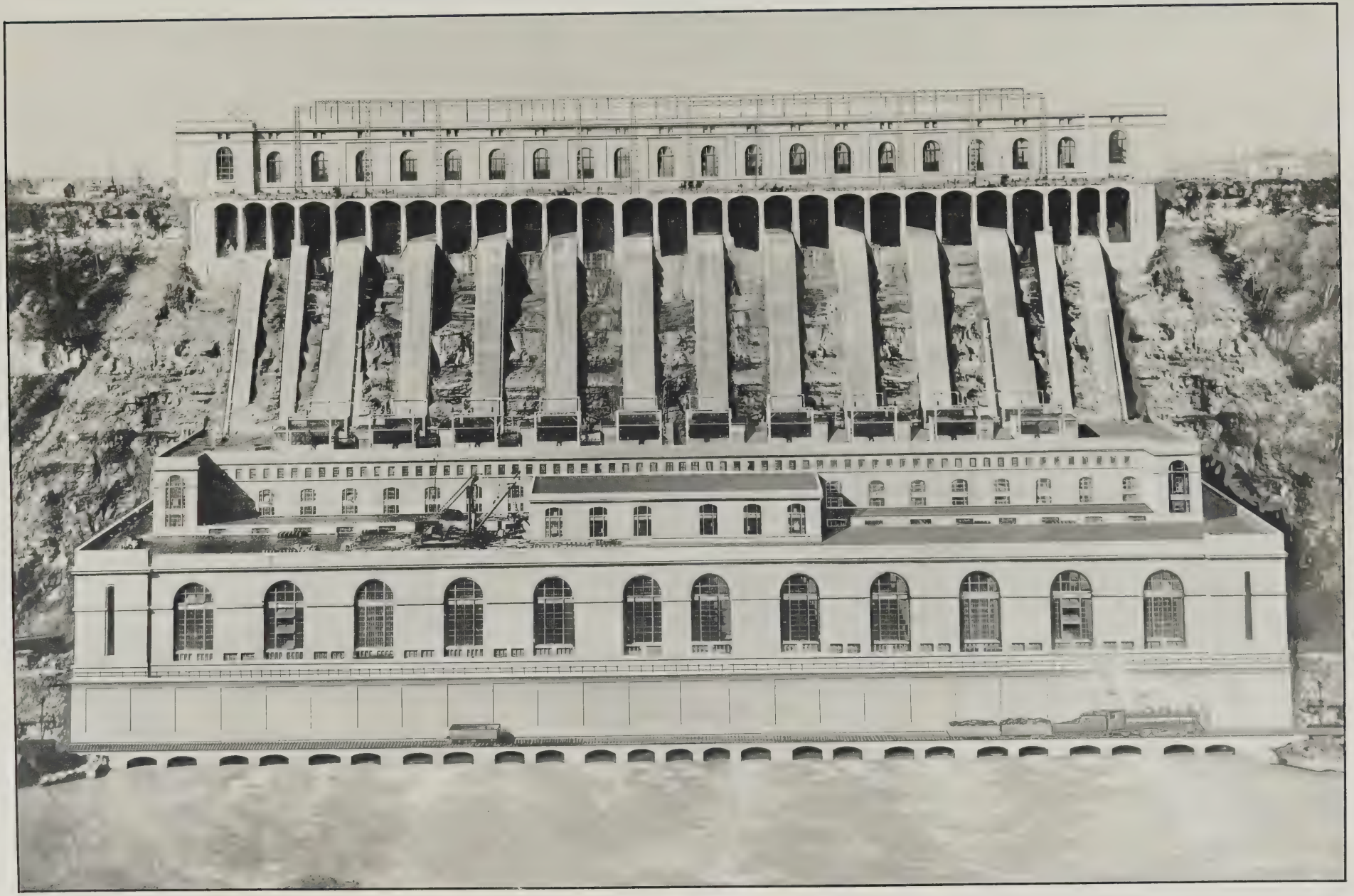
REASONS FOR INCREASED COST

The Power House of

The Queenston-Chippawa Power Development

As it will appear on completion



The Power House of

The Queenston-Chippawa Power Development

Showing Progress at October 27th, 1922

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

VOLUME I

HISTORY AND DESCRIPTION

Part I - Introduction

The plan of procedure adopted by this Commission was based on the opinion that an investigation of the cost of the Queenston-Chippawa Power Development was the first matter for its consideration, but it was found that the costs of the construction had not, at the time of its appointment, been brought up to date. In view of the fact that partial operation of the Development was commenced in December, 1921, there was probably some reason for the incomplete state of the records of the Hydro-Electric Power Commission in the Spring of 1922, and it was not until six months later that all the accounts had been distributed, thus allowing our engineering and economic investigations to take direct form.

During the period that the engineers of the Hydro-Electric Power Commission (hereafter called "the Commission") were bringing their records to a complete state, our Consulting Engineer, Mr. Walter J. Francis was, with his staff, fully occupied in preparing other data which did not require an examination of cost records and other similar information. He was, therefore, able to lay out a programme for his investigations which coincided with conditions as he found them at the time.

The questions relating to the Queenston-Chippawa Power Development as submitted to this Commission by the Letters Patent are:

1. All estimates submitted from time to time to the Hydro-Electric Power Commission of Ontario for the Queenston-Chippawa Power Development, and also all estimates for the said work submitted by the said Commission to the Government of Ontario.

2. The reasons for increases from time to time in the estimates for the Queenston-Chippawa Power Development.

3. The total cost when completed of the Queenston-Chippawa Power Development.
   (a) With five units installed.
   (b) With units installed to the full capacity of the Canal.

4. The continuous output capacity of the Queenston-Chippawa Power Development, under the conditions mentioned in Clause 3.

5. The methods of construction, supervision and management which have been employed in the Queenston-Chippawa Power Development, and whether they can justifiably be continued for the economical completion of the work.

6. (a) The quantity of water now available for use by means of the Queenston-Chippawa Canal;

   (b) The power that can be developed thereby in continuous output at the Queenston Power Station.

7. In what manner and to what extent will the price of Niagara Power be affected, if at all, by the cost of the Queenston-Chippawa Development.

After considering these questions it will be appreciated that, in order to give the information required, the investigations necessarily involved a complete audit of everything in connection with the Development. Broadly speaking, the studies made include a complete review of the reasons which made the Development necessary, the preliminary studies leading to the

scheme as finally adopted, the engineering considerations involved in proportioning the various parts of the Development, the methods of conducting the work, its management during the construction period, and finally its capacity as a producer of power, together with its relationship to other plants in the vicinity already operated by the Commission.

A study of these subjects naturally brought into review the financial aspects of the situation and the relationship between the Commission and the Government.

This investigation was instituted by the Government principally because of the fact that it was not fully aware of the conditions that had caused repeated and enormous increases in the requests for funds to meet the expenditures made by the Commission on the Development, and it considered the explanations offered by the Commission wholly inadequate. In addition to this situation the Government was attacked by many individuals and interests for its support of what was claimed to be an inefficient and extravagant undertaking. It is interesting to note that these attacks came not only from within the Province of Ontario, but from other parts of the Dominion, and also from the United States.

With a knowledge of these conditions, this Commission found it necessary to thoroughly investigate every aspect of the situation so that no ground would be left for the criticism that its report was based on superficial knowledge.

Engineering Data

Our Consulting Engineer, Mr. Walter J. Francis, C.E., commenced his studies in April, 1922, and substantially completed them by the end of August, 1923. In all, he spent over sixteen months studying the subject and compiling his reports. In submitting his reports to this Commission, he states as follows:

"The information embraced under the general title of 'Engineering Data' in regard to the Queenston-Chippawa Power Development of the Hydro-Electric Power Commission of Ontario has been prepared under the direction of the writer in compliance with the instructions of the Hydro-Electric Inquiry Commission. The Engineering Data are confined solely to matters of engineering, and do not include questions of policy nor the relations of the Hydro-Electric Power Commission with the Government of the Province. Accountancy is dealt with in this study only in regard to estimates and costs. The preparation of the data was commenced in April, 1922, and has proceeded uninterruptedly until the present time in conjunction with the studies of the workings of the Hydro-Electric Power Commission.

"The information has been formally submitted to the Hydro-Electric Inquiry Commission at intervals as prepared, following the decision reached at the commencement of the work. With each finished document were submitted the requisite number of practically facsimile working copies of the original for the use and study of the Hydro-Electric Inquiry Commission, together with a similar copy for the Chief Engineer of the Hydro-Electric Power Commission. The submissions were made in the sessions of the Hydro-Electric Inquiry Commission at which the reports were read and discussed.

"The facts have been obtained by reference to the records of the Hydro-Electric Power Commission, by conferences with the engineers and the officers of the Hydro-Electric Power Commission, by personal examination of the works, and by tests in the field and in the laboratories, and it is a pleasure to refer to the courteous co-operation of the Hydro-Electric Powesr Commission in our work. While there has been splendid co-operation on all sides, the assistance rendered by Mr. Gaby, by Mr. Acres, Mr. Hearn and Mr. Montague, by Mr. Hogg, by Mr. Blanchard, by Mr. Bradley, by Mr. Dobson and Mr. Young, and by Mr. Pierdon should be specially mentioned in referring to the engineers and officers of the Hydro-Electric Power Commission."

WJF.
A-2

Laboratory Data

Dr. Frankley Taylor, Dir. Calif. St. Forest, C.E., presented his address in April, 1936, and subsequently completed the work of assembling its experts. In addition his reports in his Committee, he stated as follows:

"The information embraced under the general title of 'Engineering Data' is edited by the Committee on Calif. State Forest Development of the Hydro-Electric Power Committee of Ontario has been prepared under the direction of the writer in accordance with the instructions of the Hydro-Electric Power Commission. The engineering data is mostly in original of engineering, and is not limited to the relations of the [illegible] with the [illegible] of the Province. Cooperation in this matter is mostly only in regard to silviculture and water. The preparation of the data was commenced in April, 1935, and has proceeded continuously until the present time in accordance with the schedule of the meetings of the Hydro-Electric Power Commission.

"The information has been formally submitted to the Hydro-Electric Commission as material is prepared, following the basic principle adopted at the commencement of the work, with each finished document under submittal the complete body of practically favorable engineering matter of the original for the study of the Hydro-Electric Power Commission, together with a similar body for the Chief Engineer of the Hydro-Electric Power Commission. The submissions were made by the members of the Hydro-Electric Power Committee as the material was finished.

"The data have been arranged by reference to the records of the Hydro-Electric Power Commission, by engineers with the assistance and the officers of the Province, and by Dr. Judd, by Dr. Fernow, by Mr. Howard, by Mr. Bradley, by Mr. Jones and Mr. Young, and by Mr. Petrie, Mr. Bourn and Mr. Montague, by Mr. Hogg, by Mr. Stansfield

Generally speaking, the documents comprise an orderly and complete history and description of the entire undertaking and are based upon data submitted and statements made by the engineers of the Commission, the accuracy of which was confirmed by Mr. Francis. This course was adopted in the interests of economy and speed. As a result the Engineering Data so prepared is in effect a statement of fact based entirely on the records of the Commission, confirmed by our Consulting Engineer, and compiled in such form as to suit the nature of this inquiry.

In addition to statements of fact, Mr. Francis has submitted to us certain conclusions based upon professional engineering knowledge and experience in reference to the quality of workmanship, the efficiency of the design to meet the requirements as a whole, and its capabilities as a producer of electrical energy. As a matter of record the following is a complete list of all reports submitted to this Commission by Mr. Francis in connection with the Development:

Reports on Queenston-Chippawa Power Development by Mr. Walter J. Francis

In addition to the above, Mr. Francis made transcriptions of the following documents prepared by the Commission:

Report on Excavation Methods and Equipment

Comments on Evidence given before the Commission by Contractors on May 18th, 22nd and 23rd, 1923.

Report on Investigations Near Liverpool
by Dr. Ralph A. Bagnold

Training of the Unemployed ..... Chapter 10

Conclusion ..... Chapter 11

Appendices Charts

In addition to the above, Dr. Bagnold made investigations of the following documents prepared by the Commission:

Report on Excursion Islands and Highways

Comments on Evidence given before the Commission by Contractors on Hwy 101, Road and Trad. 1933.

Financial Data

Our Accountants, Messrs. Price, Waterhouse & Co. were instructed to make certain investigations into the accounting records of the Commission, regarding various matters which naturally came outside the scope of the reports being prepared by our Consulting Engineer. Much of the work done in this connection by the Accountants was necessary in order that the Consulting Engineer might be supplied with information, the inclusion of which was necessary in his reports.

In addition there were matters, distinctly of an accounting nature, upon which our Accountants reported to us separately. The following is a complete list of the reports presented to us by our Accountants in reference to the Development:

Memorandum re Employee James Calvert, Patrolman, Registered on Pay Roll Records of Queenston-Chippawa Development, July 20, 1922.
Memorandum re Right-of-Way of Chippawa Plant, July 17, 1922.
Memorandum re Right-of-Way of Chippawa Plant, July 20, 1922.
Memorandum re Employees performing operations classified as Machine Shop Operations registered on the payroll records of Queenston-Chippawa Development.
Memorandum - Chippawa Plant - Re Payments to Consulting Engineers.
Memorandum - Re Camp Management, Queenston-Chippawa Development (Report dated August 8, 1922).
Memorandum - Relative to Remuneration of Executive Staff - Chippawa Plant (August 11, 1922).
Letter re Rates of Wages Paid on Queenston-Chippawa Development.
Letter re Remuneration - Members Queenston-Chippawa Power Development Staff.
Letter re Personnel of Organization for Queenston-Chippawa Power Development (B. G. Salter).
Memorandum, Re Rates of Wages Paid on Queenston-Chippawa Power Development.
Report upon Accounting Systems and Methods Employed at Niagara, in Connection with Queenston-Chippawa Power Development.
Report upon Walkerton Quarry (Report dated September 23rd, 1922).
Minutes and Correspondence re Wage Rates and Labor Conditions on Queenston-Chippawa Power Development.
Accounting Forms re Queenston-Chippawa Power Development.

Memorial Date

In addition to the above reports it has been necessary to make reference to comparative balance sheets, operating accounts and miscellaneous reports prepared by Messrs. Price, Waterhouse & Co. which contain information and data on the Development. These reports will be submitted to the Government when the work of this Commission is finally concluded.

During the course of the investigation many references have been made to the reports prepared by Messrs. Clarkson, Gordon & Dilworth, the Auditors appointed by the Government to audit the books of the Commission.

Public Hearings

While this report is largely based upon the facts and figures presented by our Consulting Engineer and Accountants, it was found necessary to conduct certain other investigations chiefly in regard to the relations existing between the Commission and the Government during the period that the Development was being constructed. Public hearings were held at Niagara Falls and at the Parliament Buildings, Toronto, at various times, the main subject then under discussion being "Estimates and Appropriations". As a part of this report we therefore present a copy of all evidence taken at these public hearings which is contained in eleven volumes. The page numbers of these volumes are as follows:

2531 - 2812) 2813 - 3029)	Niagara Falls, February 6th, 7th & 8th, 1923.
4000 - 4176	Toronto, March 20th & 21st, 1923.
4177 - 4377	Toronto, March 22nd & 23rd, 1923.
4400 - 4468	Toronto, March 26th, 1923.
4469 - 4592	Toronto, March 27th, 1923.
4593 - 4706	Toronto, March 28th, 1923.
4707 - 4804	Toronto, April 3rd, 1923.
4805 - 4840	Toronto, April 4th, 1923.
4841 - 4930	Toronto, April 5th, 1923.
5265 - 5398	Toronto, May 18th, 22nd & 23rd, 1923.

General Information

In addition to the records referred to above, reference is necessarily made to other documents of a miscellaneous character and to correspondence between this Commission, the Hydro-Electric Power Commission and others. Generally speaking copies of all such documents and correspondence will be found in our official records, but as they have a bearing upon our general work they are not attached to this report.

PART II - HISTORICAL

Section 1

CHRONOLOGICAL CHARTS

Our Consulting Engineer, Mr. Walter J. Francis, C.E., has prepared a report entitled "Chronological Charts" which we have included in this report as pages 11 to 19, inclusive. These charts show in chronological order the dates of the more important events as they occurred from the beginning of the year 1914 until August 12th, 1922, in connection with the Queenston-Chippawa Power Development. There are nine charts in all, one for each year.

Each chart is divided into three principal columns entitled "Intake and Welland River", "Canal and Forebay" and "Screen House and Power House", in order from left to right of the page. The columns are subdivided into panels by months, commencing with January at the top, and ending with December at the bottom. Further, an attempt has been made to place the notes in chronological order in each month, that is by putting the earlier ones at the top of the panel and the later ones at the bottom.

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January			
February			
March			
April			
May	Reconnaisance	Survey commenced on	May 4th.
	Level	Party commenced on	May 14th.
	Transit	Party commenced on	May 28th.
June	Comparative Survey of	"Jordan – Erie" Project commenced on	June 15th.
July			
August			
September			
October	Comparative Survey of	"Jordan – Erie" Project completed on	October 7th.
		Core drill commenced at Montrose on October 26th.	
November			
December			

1914

NOTE – THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

Hydro-Electric Inquiry Commission
W.D. Gregory – Chairman
Queenston-Chippawa Power Development
Chronological Chart
(In 9 Sheets of which this is Sheet 1)

Toronto, August 12th 1922. Made by [illegible] Checked by [illegible]
Walter J. Francis, C.E.,
Consulting Engineer

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January	Temporary Field Topographical Map	Office at Niagara Falls for Proposed Canal Location	closed January 20th. commenced January 28th.
February			
March	Topographical Map	for Proposed Canal Location	finished March 1st.
April	Studies and Preliminary Design	of Queenston - Chippawa Power	Development commenced in the Spring.
May			
June	Field Work resumed (Cross "Estimate	Sections and Topography, following № 1" finished	the Studies), June 21st. June 23rd.
July			
August			
September		Core drilling discontinued on September 15th.	
October			
November			
December			

1915

NOTE - THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

Hydro-Electric Inquiry Commission
W.D. Gregory - Chairman
Queenston-Chippawa Power Development
Chronological Chart
(In 9 Sheets of which this is Sheet 2)

Toronto, August 12th 1922. Made by ## Checked by JCB
Walter J. Francis, C.E.,
Consulting Engineer

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January			
February			
March			
April	First Act of the Ontario Legislature "The Ontario - Niagara Development Act assented to, April 27th. (6 George V., Chap. 20)."		
May			
June			
July		Well Drilling commenced to supplement Core Drill records on July 28th.	
August	Purchase of Right of Way commenced on August 16th.		
September			
October			
November		Survey for Construction Railway commenced on November 27th.	
December			

1916

NOTE - THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

Hydro-Electric Inquiry Commission
W.D. Gregory – Chairman
Queenston-Chippawa Power Development
Chronological Chart
(In 9 Sheets of which this is Sheet 3)
Toronto, August 12th 1922. Made by WJF Checked by WJF
Walter J. Francis, C.E.,
Consulting Engineer

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January			
February		R.D. Johnson's Report (Hydraulic Characteristics of Rock Section) submitted on February 1st.	
March		Large Plant Order, including six shovels Nos 1 to 6 placed on March 28th.	
April	Second Act of "The Ontario -	the Ontario Legislature Niagara Development Act, 1917, R.D. Johnson's Report (Comparative Waterways for Development of 900,000 HP) submitted on April 18th.	assented to, April 12th. (7 George V., Chap. 21)".
May		Earth Excavation began at Bowman's Gully on May 10th (Shovel No 7.) Work-train Service commenced on May 17th.	
June		Construction of Railway yards commenced on June 1st. (Shovel No 5). Study for Determination of Economic Velocity in Concrete-lined Canal commenced in June.	
July		Study of Economic Rock Section commenced in July.	
August			
September		Small Steam Shovel No 7, ordered on September 13th. A.C. Douglass's Report on probable Cost of Rock and Earth Excavation (with other papers) submitted on September 19th. and 24th.	Clearing of Power House Site commenced on September 29th.
October			
November			
December	"Estimate No 2"	Canal Cut commenced by first Electric Shovel on December 15th. (Shovel No 3). for (300,000 H.P.) submitted on	December 26th.

1917

NOTE - THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

Hydro-Electric Inquiry Commission
W.D. Gregory – Chairman
Queenston-Chippawa Power Development
Chronological Chart
(In 9 Sheets of which this is Sheet 4)

Toronto, August 12th 1922. Made by [illegible] Checked by [illegible]
Walter J. Francis, C.E.,
Consulting Engineer

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January		Shovel No 4 commenced in Canal Cut on January 12th.	
February		Operation of Whirlpool Substation commenced in February.	
March		Rock drilling commenced in Forebay on March 2nd. Rock drilling commenced in Canal on March 9th. Shovel No 1. (first large electric shovel) commenced in Canal Cut on March 16th.	
April		Shovel No 2. (second large electric shovel) commenced in Canal Cut on April 13th.	
May	Lidgerwood Cableway commenced on May 13th.	Shovel No 4 commenced stripping in Canal and Forebay on May 11th.	
June	Models installed at Dufferin Islands in June to study Design of Intake.		
July		Two Electric Shovels. (No 8 large and No 9 small), ordered on July 6th. R.D.Johnson's Report on Study of Ice Skimmer and Canal Bends submitted on July 30th.	
August			
September	Dredge "Charles Boone" commenced at Chippawa on September 13th.	Shovel No 4 commenced excavating Rock in Canal, first bench, on September 10th. Crusher Plant commenced	on September 30th.
October	First Experiments on Models for Intake completed on October 22nd.		
November			
December			

1918

NOTE - THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

Hydro-Electric Inquiry Commission
W.D. Gregory – Chairman
Queenston-Chippawa Power Development
Chronological Chart
(In 9 Sheets of which this is Sheet 5)

Toronto, August 12th 1922. Made by ~~H~~ Checked by JCA
Walter J. Francis, C.E.,
Consulting Engineer

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January	R.D. Johnson's Report on Study of Intake for 15,000 cu. ft. per sec. submitted on January 31st.		
February			Generators for Main Units 1 and 2 ordered on February 7th.
March		Estimate of Additional Cost of Canal Concrete Lining Plant submitted in March	
April		Shovel No 9. commenced in Rock Cut on April 18th.	Rock Excavation commenced on cliff on April 12th.
May		Small Steam Shovel No 10, ordered on May 10th. Shovel No 8 (third large electric shovel) commenced in Rock Cut on May 19th.	
June		Shovel No 10 commenced in Rock Cut on June 17th.	
July			Excavation commenced for Siding to Power House (Shovel No 6) on July 17th. Turbines for Main Units 1 and 2 ordered on July 25th.
August		First Concrete placed in Whirlpool Transition on August 26th.	
September			
October			
November	Second Experiments on Models for Intake completed on November 5th.	Operation of Montrose Substation commenced on November 26th.	Excavation commenced for Power House (Shovel No 4) on November 15th.
December			

1919

NOTE - THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

HYDRO-ELECTRIC INQUIRY COMMISSION
W.D. GREGORY - CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT
CHRONOLOGICAL CHART
(IN 9 SHEETS OF WHICH THIS IS SHEET 6)

Toronto, August 12th 1922. Made by [illegible] Checked by [illegible]
WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January			
February			Generators for Main Units 3, 4, 5 and all Main Transformers ordered on February 26th
March	R.D.Johnson's Report on Design of Intake for 15,000 cu. ft. per sec. based on 1919 experiments submitted on March 1st.		
April			Large Johnson Valves ordered on April 5th.
May	Parliamentary Commission, under	Chairmanship of Edgar Watson, M.P.P.,	appointed on May 19th.
June	R. D. Johnson's "Report on Parliamentary Commission General Strike went into	Queenston-Chippawa Development," submitted Report to Lieutenant-Governor effect, with exception of Construction	submitted on June 1st. on June 4th. Railway Operators on June 16th.
July	All work Temporary dam for Intake Commenced on July 29th.	resumed on July 12th after Large Steam Shovel No11 ordered on July 12th.	the General Strike. Turbines and Governors for Main Units 3, 4 and 5 ordered on July 20th.
August	Hugh L. Cooper & Co's "Letter of	Transmittal" with Estimates of Cost, Large Steam Shovel No12 ordered on August 14th	submitted on August 7th.
September	General Report by Francis Lee	Paving Plant No2 commenced concreting Canal floor on September 17th. Stuart and H. S. Kerbaugh submitted	on September 30th.
October	P.A.Schoellkopf's Report on Elevation of Chippawa Pool submitted on October 18th. Hugh L. Cooper & Co's R.S.Lea's Report on Chippawa-Grass Island Pool	Shovel No11 (first large steam shovel) commenced excavating in Canal on October 6th. "Final Report" submitted on and Canal Design submitted on October 26th.	Penstocks ordered on October 14th. October 22nd.
November		Control Gate ordered on November 16th. Lining Plant No1 commenced Concreting Canal Walls on November 18th. Shovel No12 (second large steam shovel) commenced excavating in Canal Cut on November 25th.	Concreting Plant commenced at Power House on November 8th.
December		Dredge "Cyclone" arrived at Chippawa on December 10th	

1920

NOTE - THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

HYDRO-ELECTRIC INQUIRY COMMISSION
W.D.GREGORY - CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT
CHRONOLOGICAL CHART
(IN 9 SHEETS OF WHICH THIS IS SHEET 7.)

Toronto, August 12th 1922. Made by [illegible] Checked by [illegible]
WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January			
February			Service Turbines ordered on February 4th Concreting Plant commenced at Screen House on February 13th.
March		Dredge "Cyclone" commenced Excavating in Earth section of Canal on March 14th.	
April		Whirlpool Concreting Plant commenced on April 13th.	
May			Ice Chute Gates ordered on May 5th.
June		Forebay Concreting Plant commenced on June 17th.	
July	Lidgerwood Cableway finished on July 2nd.	Shovel Nº10 finished on July 2nd.	
August			
September		Dredge "Cyclone" finished on September 3rd. Shovel Nº7 finished on September 21st. Shovel Nº9 finished on September 24th.	
October		Shovel Nº3 finished on October 14th. Shovel Nº5 finished on October 21st. Shovel Nº4 finished on October 25th.	
November		Dredge "Niagara" commenced in November. Shovel Nº 1 finished on November 8th. Shovel Nº 8 finished on November 18th. Shovel Nº 2 finished on November 27th. Shovel Nº11 finished on November 29th. Shovel Nº12 finished on November 30th.	
December	Report on Progress by Francis Lee Stuart and H. S. Kerbaugh submitted on December 13th.	Canal Lining finished on December 19th. Canal Paving finished on December 21st. Water turned into Canal, Forebay and one Penstock at 4.25 a.m. on December 24th. Whirlpool Concreting Plant finished on December 24th. Canal Retaining Wall finished on December 30th.	Main Unit No.1 commenced turning on December 28th at Official Opening

1921

NOTE - THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

HYDRO-ELECTRIC INQUIRY COMMISSION

W.D. GREGORY – CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

CHRONOLOGICAL CHART

(IN 9 SHEETS OF WHICH THIS IS SHEET 8)

Toronto, August 12th 1922. Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

	Intake and Welland River	Canal and Forebay	Screen House and Power House
January		Dredge "Niagara" finished on January 25th.	Main Unit №1 put into service on January 6th.
February			Main Unit №2 commenced turning on February 21st.
March			
April	Unwatering of Intake Cofferdam commenced on April 1st. Hydro-Electric Inquiry Commission Contract for Construction of Intake dated April 26th.	under Chairmanship of W.D. Gregory	appointed on April 13th.
May			
June			Main Unit №2 put into service on June 1st.
July			Main Unit №3 commenced turning on July 25th.
August	Excavation in Welland River resumed in August.		
September			
October			
November			
December			

Note:- This Sheet completed to August 12th.

1922

NOTE - THIS CHART REFERS ONLY TO THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

Hydro-Electric Inquiry Commission
W.D. Gregory - Chairman
Queenston-Chippawa Power Development
Chronological Chart
(In 9 Sheets of which this is Sheet 9)

Toronto, August 12th 1922. Made by WJF Checked by JDL
Walter J. Francis, C.E.,
Consulting Engineer

Section 2

H I S T O R Y

The following section is largely based on a report prepared by our Consulting Engineer entitled "Chapter B - History".

For a number of years, and prior to any detailed investigation of the project which is now known as the Queenston-Chippawa Power Development, the engineers of the Commission appreciated the ultimate necessity of utilizing all the water available from Niagara Falls in the most efficient way possible. The amount of water which could be diverted from the river under the International Waterways Treaty being limited in quantity, the engineers considered it essential that it should be converted into electrical energy under the greatest possible head. In the past the plants developing electric power at Niagara were using only the head available immediately at the Falls, whereas between Lake Erie and Lake Ontario there is a difference in elevation of about twice that amount. The problem resolved itself into the determination of the best plan to take advantage of this greater head. WJF. B-1.

As early as the year 1900 a number of independent engineers had conceived various projects for developing the water from Niagara Falls under a greater proportion of the total head between Lake Erie and Lake Ontario than had hitherto been considered, some of these projects proposed bringing the water from Lake Erie across the Niagara Peninsula by means of the existing waterways and artificial canals at a location some miles west of the Niagara River, with a power house located in the vicinity

Section 1

NIAGARA

The following section is largely based on a report presented by our Consulting Engineer entitled "Chapter 3 - Niagara".

For a number of years, and prior to any detailed investigation of the project which is now known as the Queenston-Chippawa Power Development, the engineers of the Commission appreciated the attractive possibility of utilizing all the water available from Niagara Falls in the most efficient way possible. The amount of water which could be diverted from the river under the International Treaties then in force, is limited in quantity, the engineers considered it essential that it should be conserved into eleventh hour for the greatest possible head. In the past its ultimate development stage was taken only the head available immediately at the Falls, whereas between Lake Erie and Lake Ontario there is a difference in elevation of about three hundred feet. This provides received itself into the determination of the best plan to take advantage of this greater head.

P-1.
M.U.

In early in the year 1920 a number of independent engineers and economic writers developed the water from Niagara Falls under a diversion in the total head between Lake Erie and Lake Ontario into any existing waterway, some of these projects provided bringing the water from Lake Erie across the Niagara Peninsula by means of the existing waterways and artificial canals at a location near mile west of the Niagara River, with a power house located in the vicinity

of the village of Jordan. These projects were variously known as the Jordan-Erie project and the Erie-Ontario project. Still other projects were based upon a form of development closer to the Niagara River. WJF. B-2.

By the year 1913 the engineers of the Commission decided that the time had arrived when definite steps would have to be taken to provide a larger supply of power for the Niagara System. It was therefore decided to give more attention to the study of the relative merits of the different methods of developing under the maximum possible head the available flow that might be withdrawn from Niagara Falls. To this end a reconnaissance survey for the Queenston-Chippawa Power Development was started on May 4th, 1914, and during the same month level and transit parties were also placed in the field. This survey was carried out during the year 1914, the engineers occupying a temporary office at Niagara Falls. Early in 1915 the temporary office was closed and the staff taken to Toronto. The preparation of a complete topographical plan was then commenced. This plan was completed on March 1st, 1915. WJF. B-2.

Coincident with this work, a survey of the suggested "Jordan-Erie" method of development was also undertaken in order that a proper comparison might be made between the various projects. The "Jordan-Erie" survey was completed on October 7th, 1914.

In order to obtain definite data regarding the location of the rock surface throughout the length of the Queenston-Chippawa Power Canal, a core drill commenced working on October 26th, 1914, and made borings continuously until September 15th, 1915.

With the aid of the data so obtained, sketches of preliminary designs were prepared for a development of 100,000 horse-power, and in June, 1915, an estimate of cost, known as Estimate No. 1, was submitted to the Commission. The engineers of the Commission state that this estimate was always of a preliminary nature and was prepared solely as a justification for the continuance of the surveys. WJF. B-3.

Additional survey work was thereupon approved, and on June 21st, 1915, field work was recommenced with particular reference to the details of cross sections and topography.

The first Act of the Ontario Legislature empowering the Commission to proceed with the construction of the Queenston-Chippawa Power Development was assented to on April 27th, 1916, and was entitled "The Ontario Niagara Development Act" (6 George V, Chap.20). A second Act, enlarging upon the first, and entitled "The Ontario Niagara Development Act 1917" (7 George V, Chap.21) was assented to on April 12th, 1917.

During the year 1916 the surveys and detail studies for designs were carried on continuously with the requisite field and office staff. In the summer of the same year well-drilling was carried on for the purpose of supplementing the core drill records and of obtaining exact information regarding the stratification and nature of the underlying rock throughout the canal and power house location. In the Fall of 1916 the field parties devoted their time to the surveys for the construction railway. WJF. B-3.

As a result of the studies made during the year 1916, orders were placed for a large quantity of construction equipment, most of which was delivered during the latter part of 1917.

The first excavation was commenced with No. 7 steam shovel in May of 1917, at Bowman's Gully, opposite the whirlpool. On June 1st, 1917, the second steam shovel (No. 5) was put to work for the construction of the railroad yards. On September 29th, 1917, the clearing of the power house site was started. On November 17th, a third steam shovel (No. 6) commenced the construction railroad cut, and on December 15th, the first electric shovel (No. 3) began on the main canal excavation. WJF. B-4.

On December 26th, 1917, a general report was prepared and submitted by Mr. H. G. Acres, Hydraulic Engineer of the Commission, covering the various studies which had been made for the development, together with detailed descriptions of the proposed construction equipment and organization. With this report there was also submitted Estimate No. 2 for 300,000 horse-power installed capacity.

On February 1st, 1917, a report was made on the hydraulic characteristics of the rock section of the power canal by Mr. R. D. Johnson, hydraulic engineer, of New York. This report was followed by a second one, dated April, 1917, by the same author, dealing with comparative waterways for the development of 900,000 horse-power. WJF. B-4.

During the year 1918 additional construction equipment was placed in commission, and the work became well under way throughout the whole of the undertaking, including the river, the canal and the whirlpool sections, and the power house.

During the latter part of 1917 and early in 1918, on account of war conditions, power supply was considered of vital necessity; and in May

of 1918 at the suggestion of the Power Controller of the United States, conferences were held between officers of the Commission and the Power Controller of the United States to consider the possibility of completing the Development within a year from that date. In July of 1918 improved conditions at the Front led to the abandonment of the suggested attempt to rush the work to completion at any cost. Consequently, during the years 1918 and 1919, the work progressed comparatively slowly, largely on account of the shortage of labour; and it is stated to have been found almost impossible to obtain anything like the requisite number of men to carry out the work efficiently.

WJF.
B-5.

During the summer of 1918 special attention was given to the studies for the intake design. A model of a section of the Niagara River was built in the Dufferin Islands Channel, and a series of experiments made to determine the best type of intake. The experiments carried out during 1918 were not entirely conclusive, and a second series of experiments was made during the Summer of the year 1919. Independent advice was also obtained from Mr. R. D. Johnson who made two reports thereon, one on January 31st, 1919, and a second on March 1st, 1920.

The excavation of rock on the cliff over the power house site was commenced on April 12th, 1919. During April, May and June of the same year, three additional electric shovels were put to work in the canal cut. On August 26th, the first concrete was placed for the canal lining at the "transition" between the whirlpool and rock sections.

In order to provide access to the power house site, excavation was commenced for a railway along the base of the cliff leading from Queenston to the site of the building in July, 1919, and five months later

a steam shovel was started on the power house excavation. WJF. B-6.

During the early part of 1920 work was continued under very unsatisfactory labour conditions which in May, 1920, culminated in a strike of all labour forces, with the exception of the train men. A parliamentary commission, under the chairmanship of Mr. Edgar Watson, M.P.P., was appointed by the Lieutenant-Governor in Council on May 19th, 1920. After due inquiry, this Commission reported to the Lieutenant-Governor on June 4th, 1920. The strike remained in effect until July, 1920, and an attempt was then made to make up for lost time by placing the work on a rush schedule. During the later months of the year additional equipment was introduced, and the concrete canal lining was commenced. On November 8th, the first concrete for the power house was placed. At the screen house the first concrete plant commenced work on February 21st, 1921. Dredging proceeded in the earth section from March to September, 1921, and in the canal section the excavation was completed by November, 1921. WJF. B-6.

During the year 1920 a number of reports were obtained from consulting engineers on various phases of the Development. These were as follows:

June 1st, 1920, General Report by R. D. Johnson,

August 7th, 1920, Preliminary Report by Hugh L. Cooper & Company, with Estimate of Cost.

September 30th, 1920, General Report by Francis Lee Stuart and H. S. Kerbaugh,

October 18th, 1920, General Report by P. A. Schoellkopf,

October 22nd, 1920, Final Report by Hugh L. Cooper & Company,

October 26th, 1920, Report on Power Canal by R. S. Lea. WJF. B-6.

No advisory reports were obtained from consulting engineers during 1921 with the exception of a Progress Report by Francis Lee Stuart and H. S. Kerbaugh, dated December 13th, 1921.

By December 21st, 1921, the concrete canal lining was completed and the water was first turned into the canal at 4:25 a.m. on December 24th. The official opening of the plant took place on December 28th, 1921, at which ceremony No. 1 main generating unit was first put into commission. WJP. B-7.

No. 2 main generating unit was being installed at the same time as No. 1 unit, and was first tried out by the contractors in April, 1922, but some days later, while still in the hands of the contractors, a minor defect developed in a detail of the ventilating equipment and the machine was closed down for repairs from the middle of April, 1922, until late in May, 1922. Unit No. 2 was finally placed in commission along with Unit No. 1 on June 1st, 1922. WJP. B-7.

The condition of the work at the present date, October 31st, 1923, may be briefly summarized as follows:

The Intake: The Intake is complete with the exception of the gathering tubes.

The Welland River: The excavation in the Welland River is complete for five units at the plant, and in progress for a sufficient capacity for Units Nos. 6, 7 and 8.

The Canal: The canal is complete with the exception of a small amount of trimming on the banks and betterments at the toe of the slopes. In the earth section, some additional excavation work may be required.

The Forebay: The forebay is complete with the exception of a small amount of trimming and some grading for the spillway.

The Screen House: The screen house is complete and in operation for five units, while the substructure is complete for nine units. The superstructure is in course of completion for Units Nos. 6, 7 and 8.

The Power House: Units Nos. 1, 2, 3, 4 and 5 are complete and in operation; Unit No. 6 is nearly complete; for Unit No. 7, the power house concrete is ready to receive the turbines, and the excavation for the penstock is in progress; for Unit No. 8, the excavation for the power house is complete and concreting is in progress. The turbines and the generators for Units Nos. 6, 7 and 8 are being manufactured; for Unit No. 9, the site is cleared and a small amount of rock has been excavated.

The power house building and the electrical equipment is in progress and in various degrees of completion corresponding to the installation of the units.

Bridges: All the permanent bridges are complete with the exception of the highway bridge at Victoria Road.

General Work: The work is generally progressing towards completion, and the necessary construction forces and commissariat are being retained, while, at the same time, salvage work is being carried on with particular reference to such scrap material as pipes and fittings, rails, fastenings, timber and mechanical equipment.

Section 3

EVOLUTION OF THE DEVELOPMENT

The data used in this section are obtained from a report prepared by our Consulting Engineer entitled "Chapter L - Evolution of the Development".

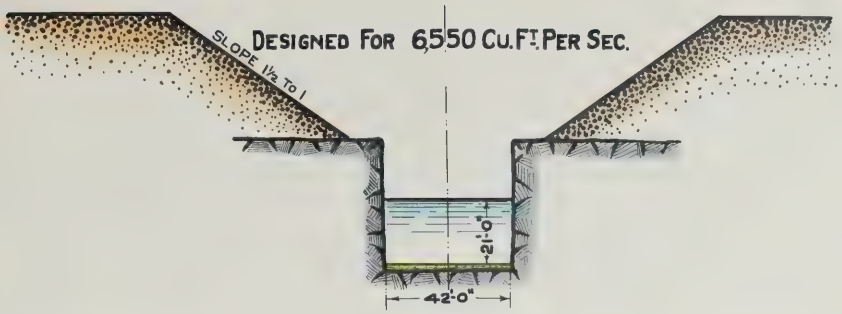
When the first studies were made of the Development with the intention of utilizing the maximum available head between Lake Erie and Lake Ontario, the preliminary designs for the development were based on a flow of 6,550 cubic feet of water per second. With this quantity in mind, the engineers of the Commission developed a canal design with a width of 42 feet and a depth of water of 21 feet. The sides of this proposed canal in the rock section were to be channelled and the floor was to be paved with concrete. A typical cross-section of this design such as would apply to the greater part of the southerly rock section of the canal, is shown in diagram A on the drawing included herewith as page 29. This design was adhered to during all the preliminary studies and estimates made in 1915 and 1916.

WJF.
L-1.

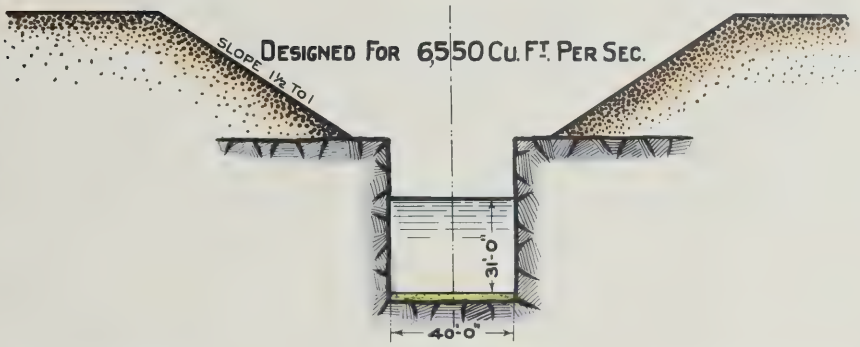
At the time these preliminary designs for the canal were being prepared a study was also made for the proposed Power House. The drawing included herewith as page 31 shows a cross section of the Screen House, Transformer House and Power House, together with the type of Penstock as then contemplated.

WJF.
L-1.

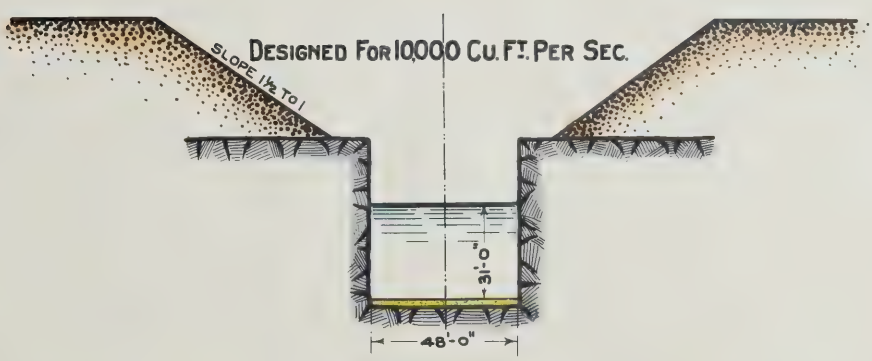
A



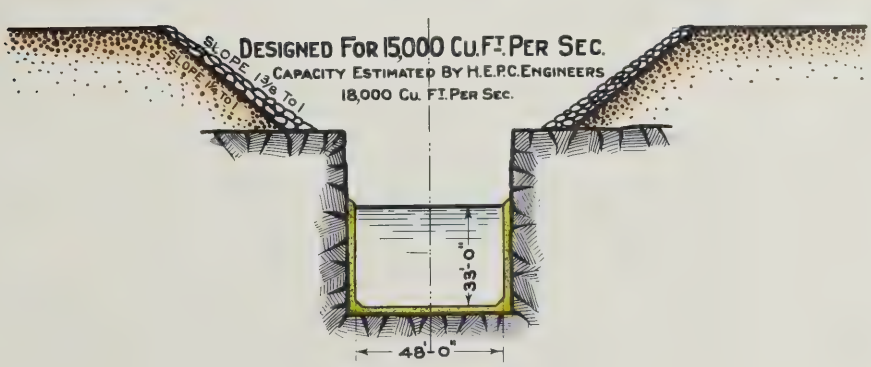
B



C



D



NOTE:—

THE ABOVE CROSS SECTIONS APPLY AT A STATION IN THE CENTER OF THE SOUTHERLY ROCK SECTION. AND ARE TYPICAL FOR THE CANAL EXCAVATED IN ROCK

Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY - CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

EVOLUTION OF THE CANAL SECTION

Scale as Indicated

Toronto, July 6th 1922 Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

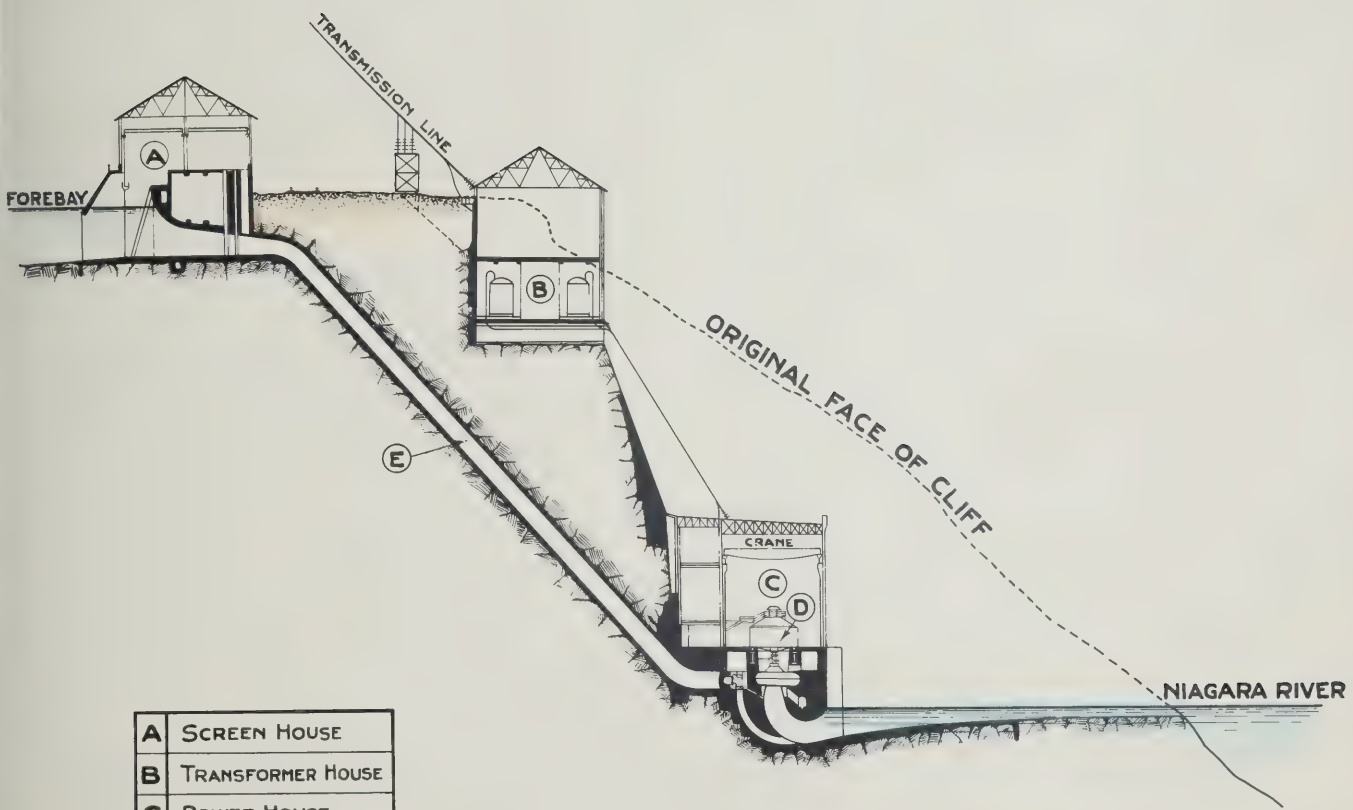
In February, 1917, Mr. R. D. Johnson, Consulting Engineer, of New York City, who had been engaged by the Commission to study characteristics of the canal section proposed, made his first report, outlining the studies he had made. The recommendations made by Mr. Johnson in this report resulted in some changes in the canal section. The width was changed from 42 feet to 40 feet, and the depth of water was increased from 21 feet to 31 feet. A typical cross-section of the canal as then adopted is shown by Diagram B on the drawing already referred to and included herewith as page 29.

Early in 1917 the possibility of obtaining control of the Ontario Power Company's plant is stated to have led to the decision to increase the capacity of the Development. A flow of 10,000 cubic feet per second corresponding to an output at the power house of 300,000 horsepower was then adopted. It is stated that the engineers of the Commission considered that with the Ontario Power Company's plant under their control, it would be desirable to withdraw some of the water used at that plant and utilize it under greater efficiency in the Queenston-Chippawa plant.

WJF.
L-4

For the capacity of 10,000 cubic feet per second, a canal was designed with a width of 48 feet and a depth of water of 31 feet. The sides of the canal in rock were still to be channelled, and the bottom was to be paved with concrete in the same manner as that contemplated in the original design. A typical cross section of this design of the canal is shown in Diagram C on the drawing included herewith as page 29.

WJF.
L-5.



A	Screen House
B	Transformer House
C	Power House
D	Generator
E	Penstock

As Proposed June 1915

0 10 20 30 40 50 60 70 80 90 100 150 200

Scale of Feet

Hydro-Electric Inquiry Commission

W. D. Gregory - Chairman

Queenston-Chippawa Power Development

Study of Projected Power House

June 1915

Scale as Indicated

Toronto, June 9th 1922 Made by CMD Checked by JCB

Walter J. Francis, C.E.,

Consulting Engineer

Following further studies of the hydraulic characteristics of the canal, with particular reference to its capacity, it wassdecided late in the year 1917 to increase the depth of the rock-cut, so as to provide 33 feet of water instead of 31 feet as heretofore contemplated, still retaining, however, the flow at 10,000 cubic feet per second. WJF. L-5.

Early in the year 1918, it is stated that the increase in demand for power led the engineers of the Commission to carry out further studies with the object of providing a canal with a larger capacity than that of any of the previous designs. After consultation with Mr. Johnson, they concluded that it would be possible to provide for a flow of 15,000 cubic feet per second, the equivalent of an output of 450,000 horse-power with comparatively little increase in the cost of t e canal. The additional flow was to be obtained by improving the hydraulic characteristics of the canal rather than by increasing its cross-sectional area. To this end a concrete lining was substituted for the channelled rock sides leaving the neat dimension of the canal at 48 feet wide with 33 feet of water. Diagram D on the drawing included herewith as page 29 shows the type of section ultimately adopted and constructed. WJF. L-5.

Upon the canal being put into operation, the engineers of the Commission made further detailed studies of the behaviour of the water with particular reference to such elements of their calculations as heretofore could only be determined on a theoretical basis, and they have now calculated that the finished canal will in all probability pass 18,000 cubic feet per second giving an output of about 540,000 horse-power. The matter of capacity of the whole Development will be discussed in greater detail in another section of this report. WJF. L-6

in another section of this report.»

I-8
R.T.P.

Following Denton studies of the feasibility of generation at the canal, with particular reference to its capacity, it appeared that by the year 1917 it increase the depth of the canal, or as is possible to put weir at Denton instead of 15 feet as mentioned above, will increase existing, however, the time at 10,000 cubic feet per second.

I-8
R.T.P.

Early in the year 1916, it is stated that the increase in demand for power had the engineers of the Commission to carry out further studies with the object of providing a canal with a larger capacity than that of any of the previous designs. After consulting with Dr. Johnson, they considered that it would be possible to provide for a flow of 24,000 cubic feet per second, like explained at an outlay of $8,000,000 with comparatively little increase in the cost at 17 miles. The additional flow was to be obtained by improving the hydraulic characteristics of the canal section thus by increasing the wetted-perimeter ratio. In this case a separate lining was substituted for the economical rock slope lining the most economical at the canal at 24 feet wide with 32 feet of water.

I-8
R.T.P.

Diagram 3 on the drawing included herewith on page 83 shows the type of section ultimately adopted and constructed.

Upon the canal being put into operation, the engineers of the Commission made further detailed studies of the behaviour of the water with particular reference to such elements of their calculations as hydraulic gradient which could only be determined on a semi-actual basis, and they have now completed that the flushed canal will in all probability pass 18,000 cubic feet per second giving an output of about 360,000 horse-power. The matter of capacity of the whole development will be discussed in greater detail

Section 4

ADVISORY REPORTS

In other parts of this report, we refer to advisory reports made to the Commission by various consulting engineers and contractors. Our Consulting Engineer has submitted a statement referring to these advisory reports in his report, "Chapter C - Advisory Reports". For the sake of brevity we repeat here only a summary of the principal recommendations made by the advisory engineers and the disposition thereof:

Summary of Recommendations

Author and Date	Recommendation	Disposition
R. D. Johnson, February 1, 1917	(a) Canal section should be in proportion of 1 to 1 instead of 2 to 1	Adopted.
	(b) For basis of calculations elevation 558 for Chippawa Pool is recommended	Adopted in part, but a higher elevation was used for fixing the effective capacity of the project.
	(c) Provision for a rise of 6 feet in forebay due to surges	Adopted.
R. D. Johnson, April 18, 1917	(a) Adoption of a pressure tunnel project	Not adopted, and at later date Mr. Johnson admits that canal project is preferable.
A. C. Douglass, September 19, 1917 September 24, 1917	(a) Estimates Cost at $1.56 per cu.yd. for rock excavation ..... (b) $0.35 per cu.yd. for earth excavation ..... (c) $6.50 per cu.yd. for concrete	These excavation figures were not adopted by the H.E.P.C. engineers for the reason that they were based on steam shovel practice instead of on electrical equipment.

Section 1

In other parts of this report, no value is entered opposite to the Consulting Engineer has submitted a statement referring to those already remarks in his report. Compare C - Statutory Reports. As the make or formally be raised here only a summary of the principal recommendations of the statutory engineers and the disposition thereof.

Summary of Recommendations

Letter and Date	Recommendation	Disposition
M. P. Jackson, February 3, 1917	(a) Tunnel section should be in proportion of 1 to 2 in height.	
	[illegible]	
	[illegible]	
	[illegible]	
	That an investigation [illegible]	
	[illegible]	
	[illegible]	
	[illegible]	
	[illegible]	
M. M. Johnson, April 14, 1917	(a) Acquisition of a [illegible]	
	Tunnel typical	Not adopted, and at later date it, Johnson admitted that tunnel project is preferable.
A. L. Bengough, September 15, 1917 December 31, 1917	(a) Estimates Cost at $3.66 per cu.yd. for rock excavation [illegible]	Three separate figures were set aside by the Engineer for his guidance.
	[illegible]	[illegible]
	(a) $4.82 per cu.yd. for tunnel excavation [illegible]	Tunnel not [illegible]
	[illegible]	[illegible]
	[illegible]	[illegible]
	[illegible]

Author and Date	Recommendation	Disposition
R. D. Johnson, July 30, 1918	(a) A constant radius for each side of canal at the bends ..	Adopted.
	(b) Ice Chute to run partly full	Adopted.
	(c) Skimmer for full width of canal	Not adopted for present but provision made for future installation if found advisable.
	(d) Concrete lining for canal with deeper excavation	Adopted.
R. D. Johnson, March 1, 1920	(a) Recommendations for design of Intake	Partly adopted with provision for complete adoption in future.
R. D. Johnson, June 1, 1920	(a) Approves canal project rather than tunnel	
Hugh L. Cooper & Company, August 7, 1920 October 22, 1920	(a) Elevation of Chippawa Pool as 558.0 instead of 560.5 ...	Not adopted.
	(b) Increase of slope of canal floor	Not adopted.
	(c) Skimming works in forebay ...	Not adopted for present, but provision made for future installation if found advisable.
	(d) Additional distribution system in forebay	Previously adopted.
	(e) Abandoning intake design and substituting fixed boom .	Not adopted.
	(f) Bonus system for labour	Not adopted.
	(g) Whirlpool section should be tested with water	Not adopted.
	(h) Slopes of whirlpool section should be 2 to 1	Not adopted.
	(i) Plant should be increased to 20,000 cu.ft.per sec.capacity	Not adopted.
Stuart & Kerbaugh September 30, 1920	(a) Additional crushing plant and sale of stone	Adopted in part.
R. S. Lea, October 26, 1920	(a) Elevation of pool should be taken at 559.5	Adopted at time, but modified later.

PART III - GENERAL DESCRIPTION

Section 5

G E N E R A L

A very complete and detailed description of the plant as built is contained in our Consulting Engineer's report entitled "Chapter E - General Description". It contains a number of plans illustrating in general detail the main elements in the whole Development, and photographs showing portions of the work as now completed. For the purposes of this report we will describe in a brief manner only, the main elements and if further details are required they may be obtained by referring to the report mentioned above.

In addition to the right-of-way and crossings, which may be considered as common to the whole project, the Development consists of seven principal elements working in co-relation to provide the means of converting the potential energy of the water of the Niagara River into electrical energy. The seven elements may be briefly described as follows:

(a) The Intake, through which water is diverted from the Niagara River into the Welland River.

(b) The Welland River, where the improved river channel is utilized for the passage of the water.

(c) The Canal, which conveys the water from the Welland River to the forebay near the Power House.

(d) The Forebay, where the water is spread out or distributed over a relatively wide area.

(e) The Screen House, where the water is diverted into various channels leading therefrom.

(f) The Penstocks, being the steel tubes or pipes carrying the water from the Screen House over the cliff down to the turbines.

(g) The Power House, in which are located the turbines and the generators for converting the hydraulic energy into electrical energy. WJF. E-1.

The general location of the various elements of the Development with regard to the adjacent country is shown on the "Plan of Vicinity" included as page 37. The general location of the Development relative to the Niagara Peninsula is shown on the map forming page 38.

We will now deal in a brief way with the seven elements in the order given above:

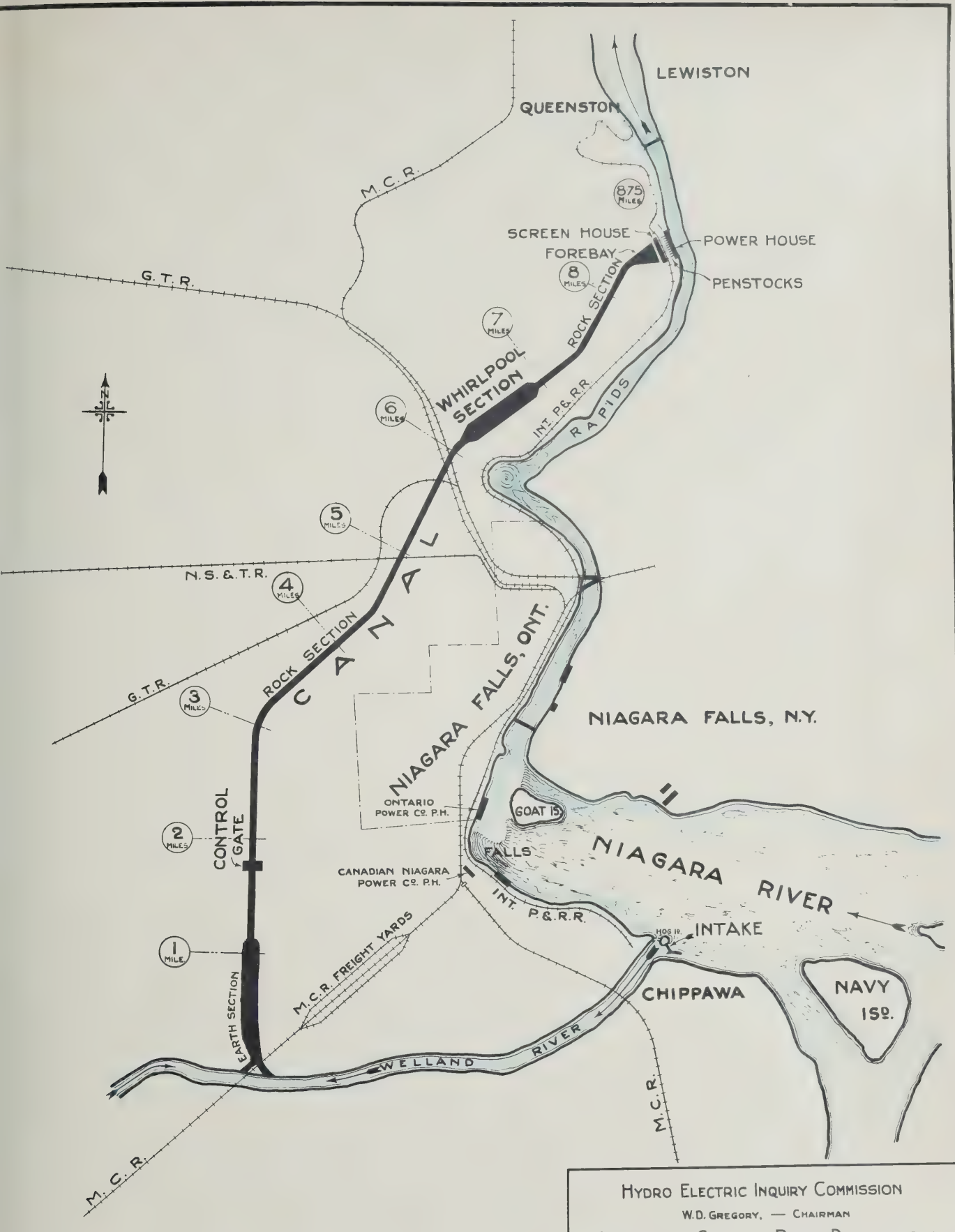
Section 6

THE INTAKE

The intake is situated at the mouth of the Welland River sometimes referred to as Chippawa Creek, adjacent to the Village of Chippawa, about two miles above the Falls of Niagara. A reference to the plan on page 37 indicates its location relative to the neighbouring parts of the Province of Ontario and the State of New York.

The design for the intake as ultimately adopted by the Commission was the result of much study. The plan as finally adopted was devised in collaboration with the engineers of the Commission by Mr. E. D. Johnson. A plan showing the present and possible future construction , entitled "Intake, Plan and Sections", is included herewith as page 39. When the intake will have been completed, the north westerly channel, on the opposite side of Hog Island will be dammed by means of an earth fill. WJF. E-7.

case of the island will be damaged by means of an earth fill".



HYDRO ELECTRIC INQUIRY COMMISSION

W.D. GREGORY, — CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

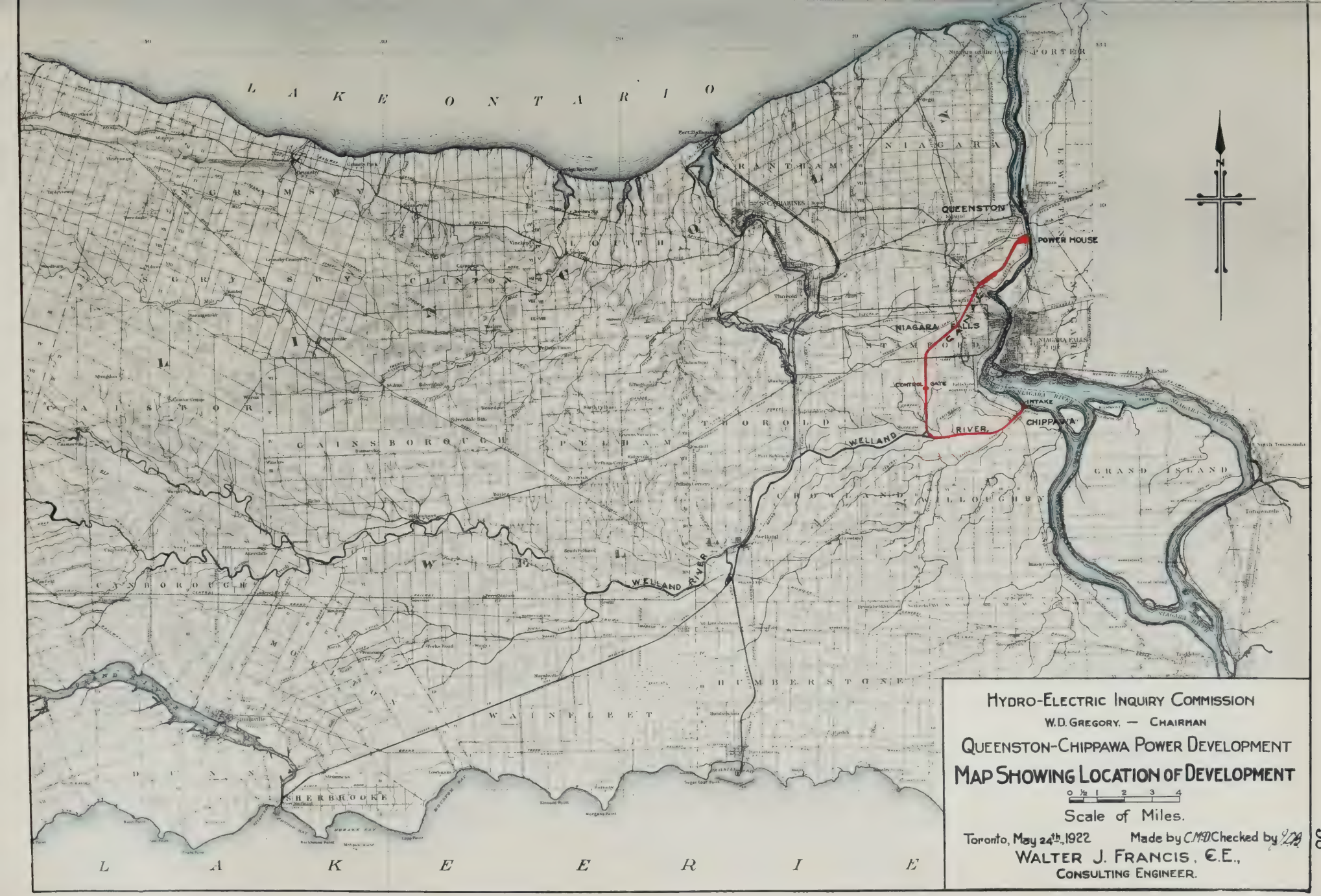
PLAN OF VICINITY

Scale of Miles

Toronto, May 16th, 1922 Made by C.M.&D. Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER.



HYDRO-ELECTRIC INQUIRY COMMISSION

W.D. GREGORY, — CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

MAP SHOWING LOCATION OF DEVELOPMENT

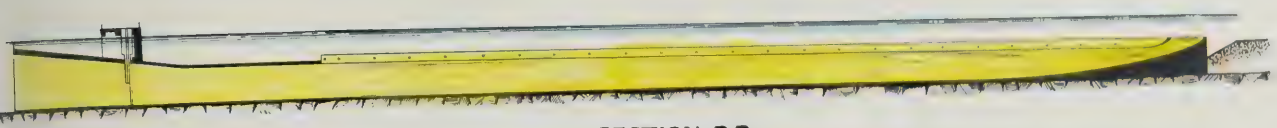
0 ½ 1 2 3 4

Scale of Miles.

Toronto, May 24th, 1922. Made by C.M.D. Checked by W.J.F.

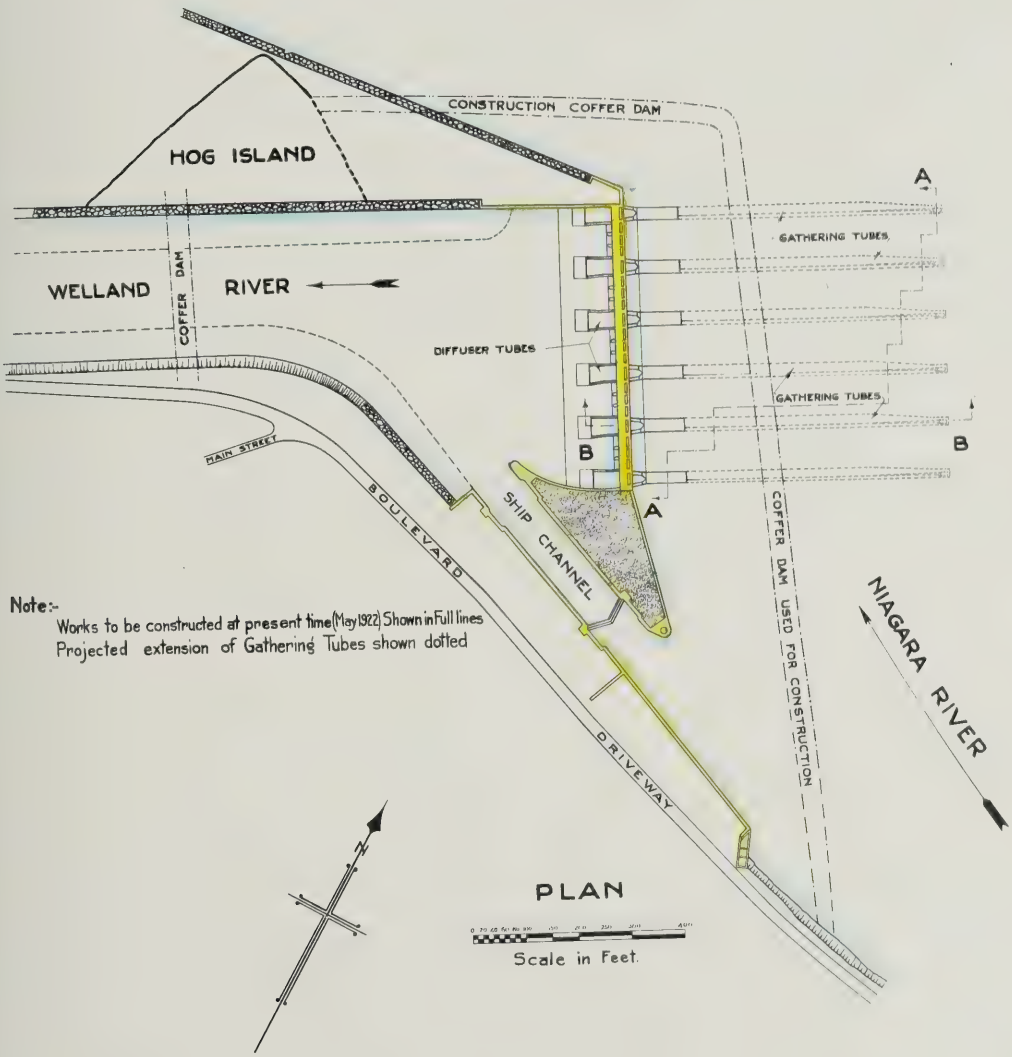
WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER.



SECTION B-B

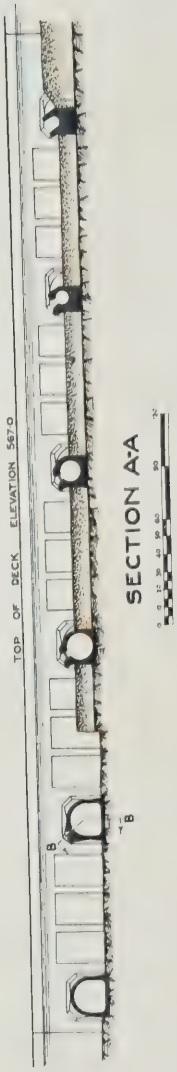
Scale in Feet



Note:-
Works to be constructed at present time (May 1922) Shown in Full lines
Projected extension of Gathering Tubes shown dotted

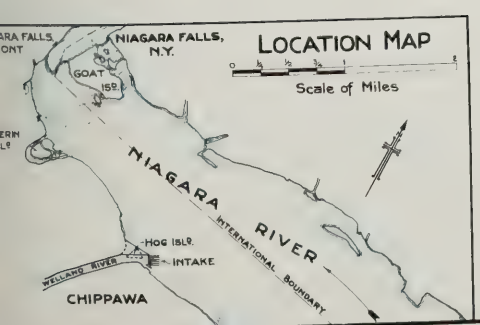
PLAN

Scale in Feet.



SECTION A-A

Scale in Feet



LOCATION MAP

Scale of Miles

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY - CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

INTAKE, PLAN & SECTIONS

Scales As Indicated

Toronto, June 6th, 1922 Made by C.M.D. Checked by W.C.B.

WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

The intake as adopted consists essentially of two parts, first, a simple culvert opening which may be used for the greater part of the time, and second, a series of special subsidiary gathering tubes, which may be used to collect water free from ice during such time as that part of the river is ice-laden.

It is to be noted that the intake design as adopted is now constructed and in operation with the exception of the gathering tubes. It is stated that the ice conditions in the river during the period that the plant is drawing sufficient water for the development of 300,000 horse-power are such that the tubes are unnecessary, and that they will not be constructed until such time as the flow of water is increased above the amount now required.

Section 7

THE WELLAND RIVER

Prior to the construction of the Development, the natural flow of the Welland River was in an easterly direction from Montrose. The slope of the river has been changed by dredging operations, resulting in reversing the direction of the flow by withdrawing water at Montrose through the canal proper, thus taking the Niagara water through the Welland River channel from Chippawa to Montrose. The natural flow of the Welland River from the watershed west of Montrose also passes into the canal through a westerly channel at the south end of the earth section of the canal.

WJF.
E-10.

The general location of this section of the river together with the profile of the bed of the river and the excavated cross-section

is shown on a drawing included in our Consulting Engineer's report, before referred to, as page E-13.

Section 8

THE CANAL

The canal commences at a point on the Welland River near the Village of Montrose and adjacent to the crossing of the Welland River by the Michigan Central Railroad, Welland-Niagara Branch, about 21,000 feet from the junction of the Welland and Niagara Rivers.

The general location of the canal is shown on the map showing location of Development included herewith as page 38 while the detailed location is indicated on the location plan, included herewith as page 42.

Generally speaking the canal passes through a country developed for agricultural purposes, and for fruit-growing. A general idea of its character may be obtained from the aeroplane photographs included herewith as pages 43 and 44.

Provision has been made for bridges over the canal for the majority of the highways existing prior to its construction and for all of the railways. It is proposed to provide a total of nine highway bridges and five railway bridges.

WJP.
E-18

As noted in the section dealing with the evolution of the Development, the canal as at present constructed was designed for a flow of 15,000 cubic feet per second. The engineers of the Commission have now reached the conclusion that the ultimate capacity of the canal as

MILES FROM JUNCTION OF CANAL AND WELLAND RIVER SHOWN THUS – (7)

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY – CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

LOCATION PLAN

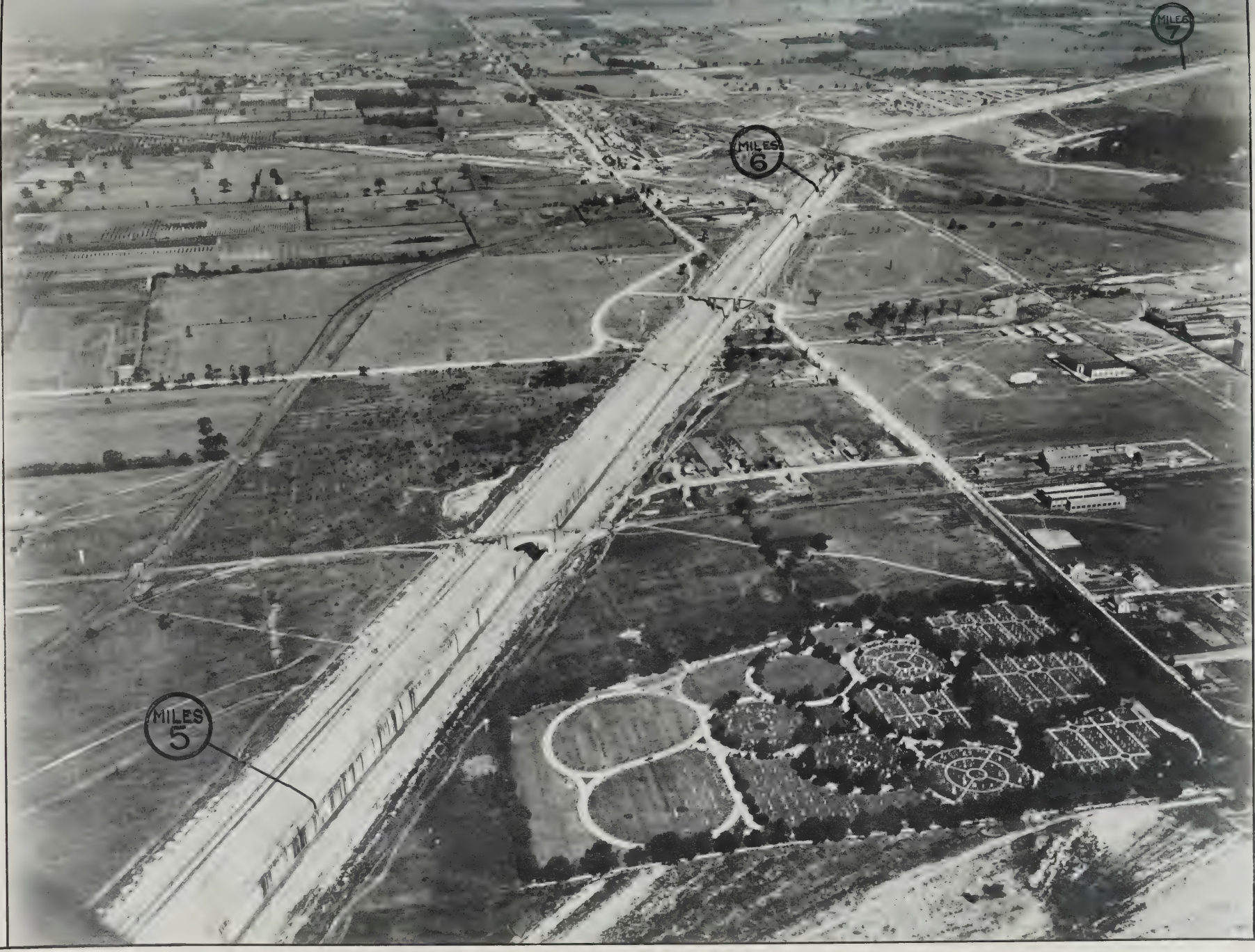
Scale of Feet

Toronto, June 17th. 1922, Made by W.W., Checked by W.G.

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

42


MILES
5
MILES
6
MILES
7


MILES 8
MILES 7
MILES 6
MILES 5

built has a greater capacity than they anticipated, and will in all probability reach 18,000 cubic feet per second.

The total length of the canal from the intersection of its centre line with the centre line of the Welland River to the beginning of the forebay is 8.58 miles. For the purpose of description it may be divided into the following sections: W.F. E-18

	From Station	To Station	Length
Earth Section	0+00	64+00	6,400 ft.
Southerly Rock Section	64+00	329+50	26,550 ft.
Whirlpool Section, including Transitions	329+50	354+00	2,450 ft.
Northerly Rock Section	354+00	452+84	9,884 ft.

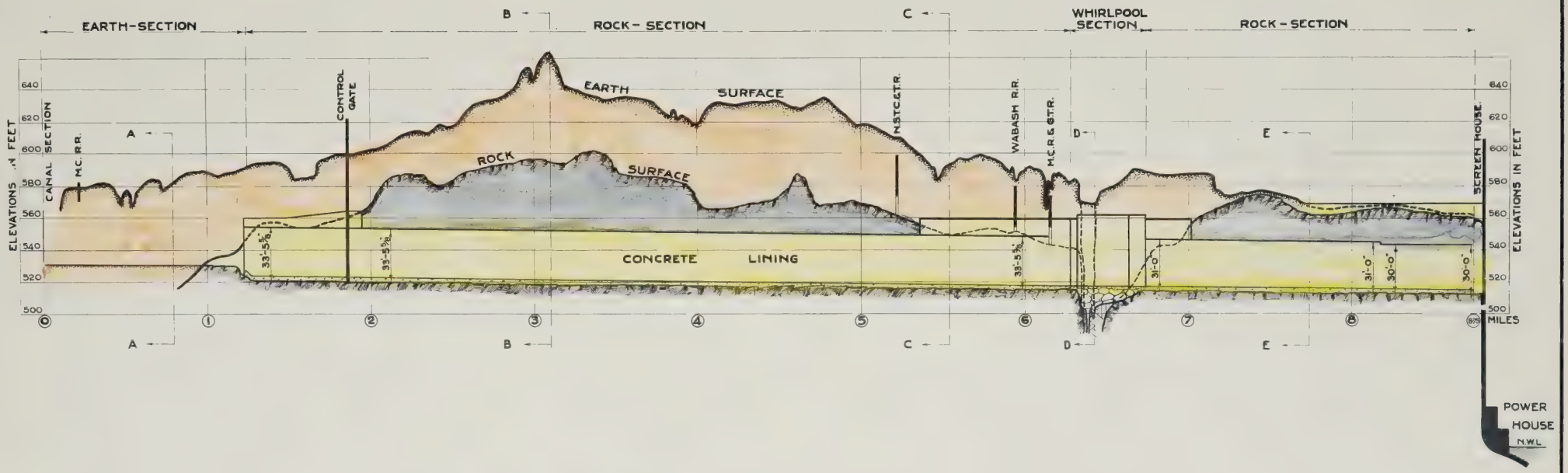
A complete description of these sections is contained in our Consulting Engineer's report, Chapter E, but we include on page 46 the profile and sections of the canal which give all the important information.

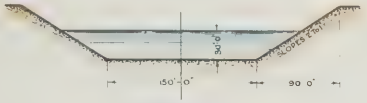
Section 9

THE FOREBAY

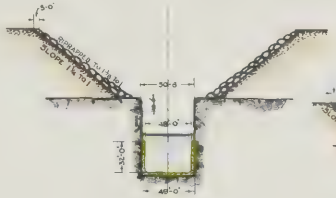
The purpose of the forebay is to provide a means of uniformly distributing the water from the canal to the various penstocks at the screen house which are spread over a width of about 500 feet.

The change in the flow of the water from the canal to the screen house has to be made in such a way as to avoid an abrupt change in the velocity in order to decrease the loss of head which would otherwise occur. This result is obtained by gradually widening the canal from a

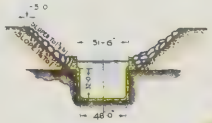




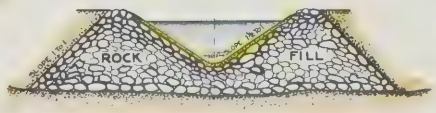
SECTION A A



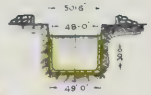
SECTION B B



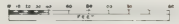
SECTION C C



SECTION D D



SECTION E E



SCALE FOR SECTIONS

EARTH SHOWN THUS:-

ROCK SHOWN THUS:-

CONCRETE SHOWN THUS:-

HYDRO-ELECTRIC INQUIRY COMMISSION

W.D. GREGORY. — CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

PROFILE & SECTIONS OF CANAL

Scales As Indicated

Toronto. May 19th. 1922 Made by C.M.D. Checked by

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

46

width of 48 feet to a width of about 500 feet at a uniform rate in a length of about 900 feet, thus forming what is referred to as the "Forebay". WJF. E-31

It can be readily understood that the water from the canal passing into the forebay at high velocity would tend to impinge upon the centre of the screen house. In order to avoid this undesirable effect a "diffuser" has been constructed at the entrance to the forebay dividing the water into two channels ensuring a more uniform velocity throughout the width of the forebay. We include herewith as page 48 a plan which shows the various elements making up this part of the Development.

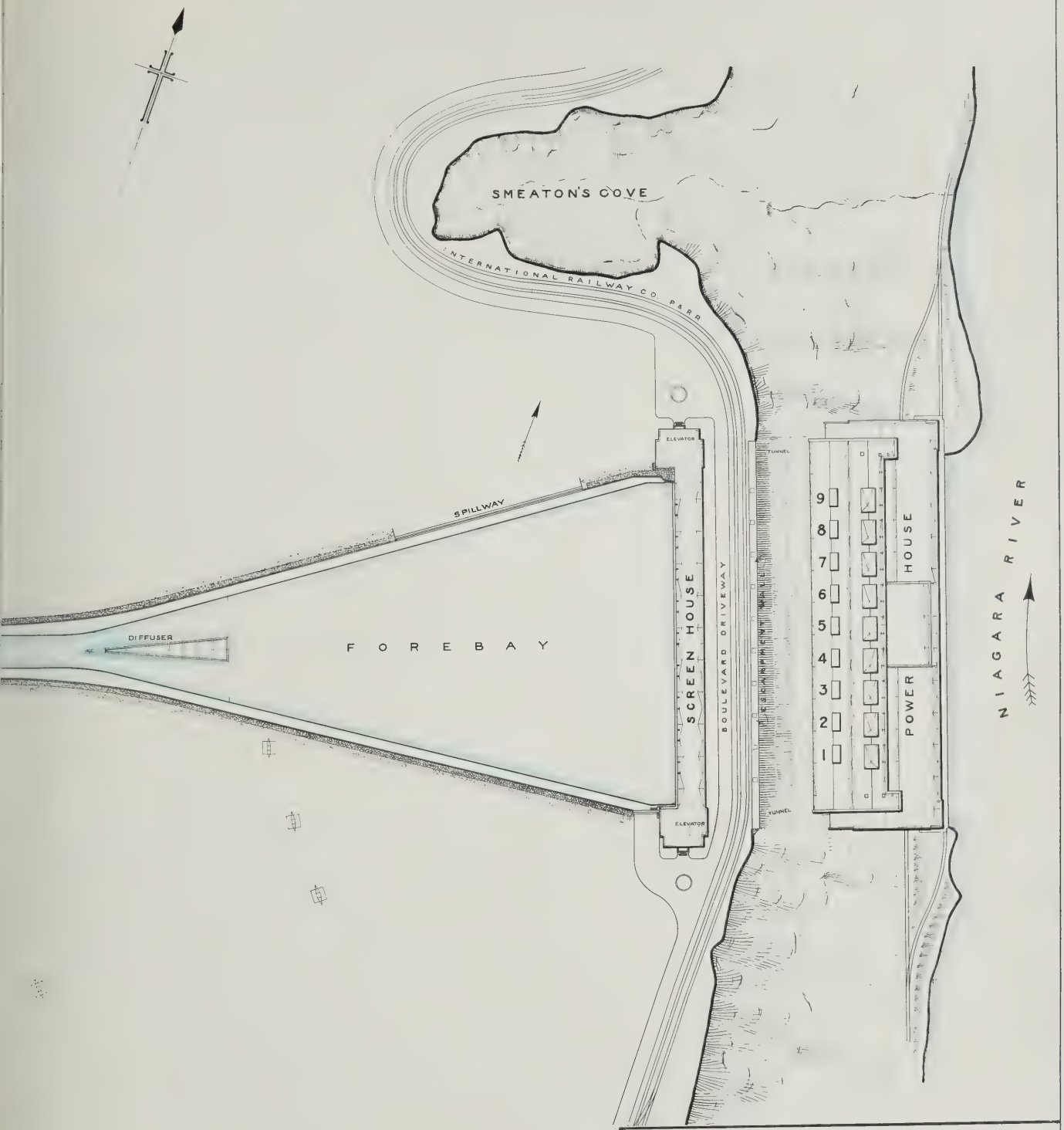
Section 10

THE SCREEN HOUSE

The general location of the screen house may be seen on the plan on page 48. The concrete substructure of the screen house is 508 feet long by 56 feet wide, founded in the solid rock which was excavated to Elevation 512.0 for the purpose. The top of the substructure is at Elevation 568.0.

The substructure primarily provides the means of admitting water from the forebay to the penstocks of which there will ultimately be ten in all, one service penstock and nine main unit penstocks, placed in order commencing after the ice chute at the southerly end of the structure. The details of construction and the manner in which the water is admitted to the penstocks is clearly described and illustrated on pages E-37 to E-42 of Mr. Francis' Report entitled "Chapter E - General Description".

The substructure is surmounted by a superstructure of steel



Plan of Proposed Final Development

Scale of Feet

Hydro-Electric Inquiry Commission

W. D. Gregory - Chairman

Queenston-Chippawa Power Development

Plan of Forebay, Screen House and Power House

Scale as Indicated

Toronto. May 18th 1922 Made by H.P.A. Checked by W.J.F.

Walter J. Francis, C.E.,

Consulting Engineer

and concrete, housing and protecting the machinery for operating the gates and handling the screens. The steel frame-work of the superstructure is extended above the roof to form one of the first of the transmission towers. WJF. E-40

At the southerly end of the screen house is located the administration building for the power house, connected therewith by an elevator operating in a shaft which is joined with the plant by a tunnel, both shaft and tunnel being excavated in the solid rock. The construction of a similarly equipped building is contemplated at the northerly end of the screen house.

The space between the screen house and the escarpment, will be finished to provide accommodation for vehicular traffic, electrical railway traffic and pedestrians.

Section 11

THE PENSTOCKS

There are ten penstocks provided in the ultimate Development, in addition to the ice chute. The ice chute is at the southerly end of the series, and about 25 feet north therefrom is the service penstock. Following in order are the main unit penstocks, 50 feet centre to centre. The ice chute is formed in reinforced concrete with an internal diameter of 10 feet. For the main units the penstock is of rivetted steel plate, encased in concrete, and it leads from the concrete lined tunnel connecting with the downstream side of the screen house through tunnel excavation in the rock to the edge of the escarpment, thence curving down with a bend over the escarpment in a trench excavated in the rock. It is joined

by a short horizontal portion to a Johnson valve adjacent to the turbine. The diameter of the upper two-thirds of the length of the main unit penstocks is 16 feet, which is reduced by means of a taper section to 14 feet for the balance of the length. WJF. B-43.

The large Johnson valve referred to above has an outlet of 10 feet in diameter and connects to the turbine casing by a number of sections of flanged cylindrical steel castings.

The penstock of the service units follows the same alignment as those for the main units, but the diameter is considerably less, being 5 feet, 6 inches throughout. Like the main unit penstocks, each of the two lower branches of the service penstock is provided with a Johnson valve. WJF. B-44.

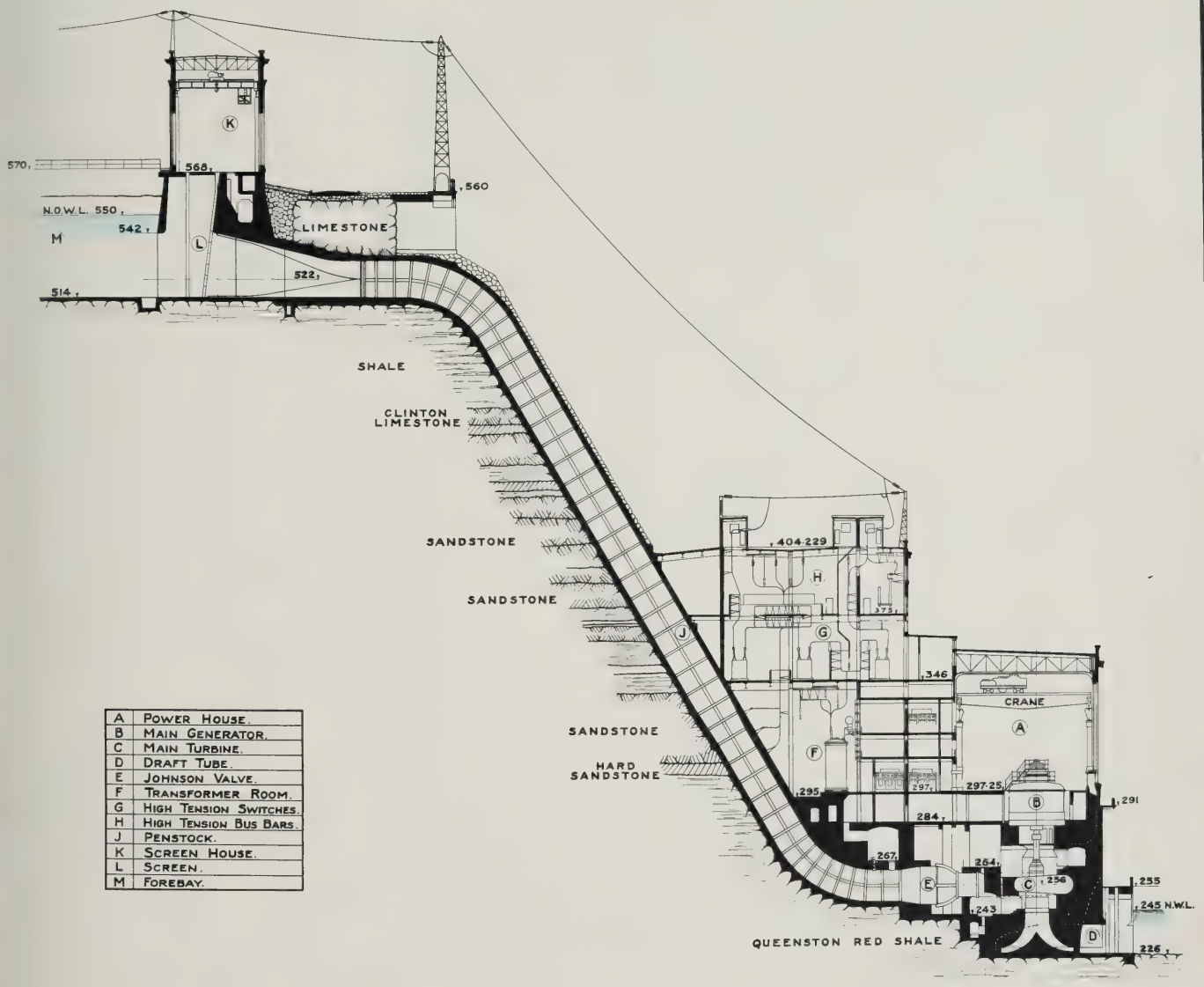
When all of the penstocks will have been finally embedded, the whole surface will be treated with gunite to prevent weathering.

We include herewith three plans as pages 51, 52 and 53 which show a general cross-section of one of the main units, the service unit and the ice shaft respectively, and the study thereof will give the relation of all of the important parts.

Section 12

THE POWER HOUSE

The power house located at the water's edge of the Niagara River directly opposite and parallel to the screen house is about 680 feet in length. Its relationship to the screen house and the forebay will be observed by referring to page 48. The building consists essentially of a substructure and a superstructure. The substructure, which



A	Power House.
B	Main Generator.
C	Main Turbine.
D	Draft Tube.
E	Johnson Valve.
F	Transformer Room.
G	High Tension Switches.
H	High Tension Bus Bars.
J	Penstock.
K	Screen House.
L	Screen.
M	Forebay.

Elevations Referred To H.E.P.C. Datum Shown Thus:- 291

Scale of Feet

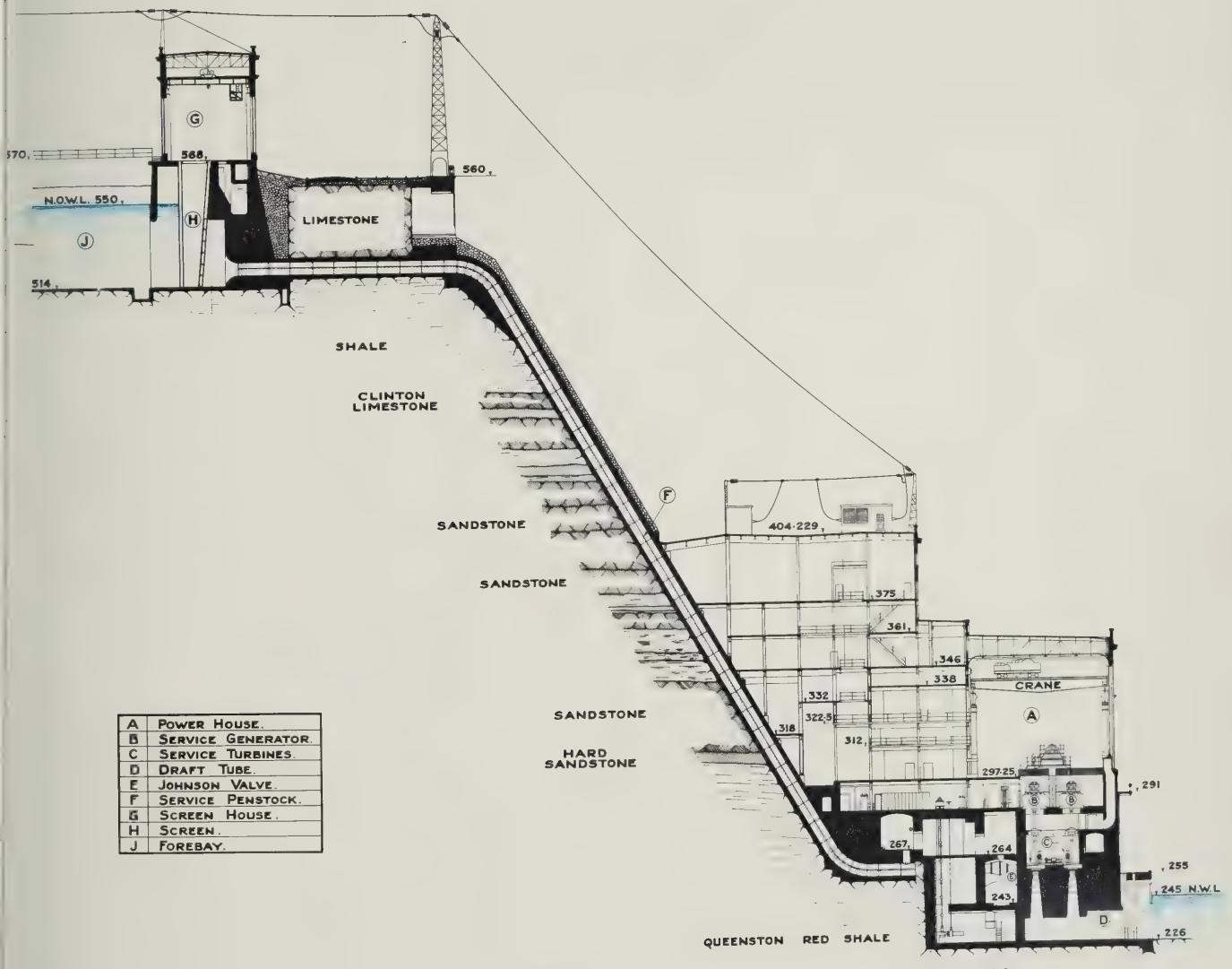
Hydro-Electric Inquiry Commission.
W. D. Gregory — Chairman.
Queenston-Chippawa Power Development.

Section Through Screen House, Main Penstock And Power House

Scale as Indicated

Toronto. May 25th 1922 Made by H.P.A. Checked by J.C.B.

Walter. J. Francis, C.E..
Consulting Engineer.



A	Power House.
B	Service Generator.
C	Service Turbines.
D	Draft Tube.
E	Johnson Valve.
F	Service Penstock.
G	Screen House.
H	Screen.
J	Forebay.

Elevations Referred To H.E.P.C. Datum Shown Thus:- 291

Scale of Feet

Hydro-Electric Inquiry Commission

W. D. Gregory–Chairman

Queenston-Chippawa Power Development

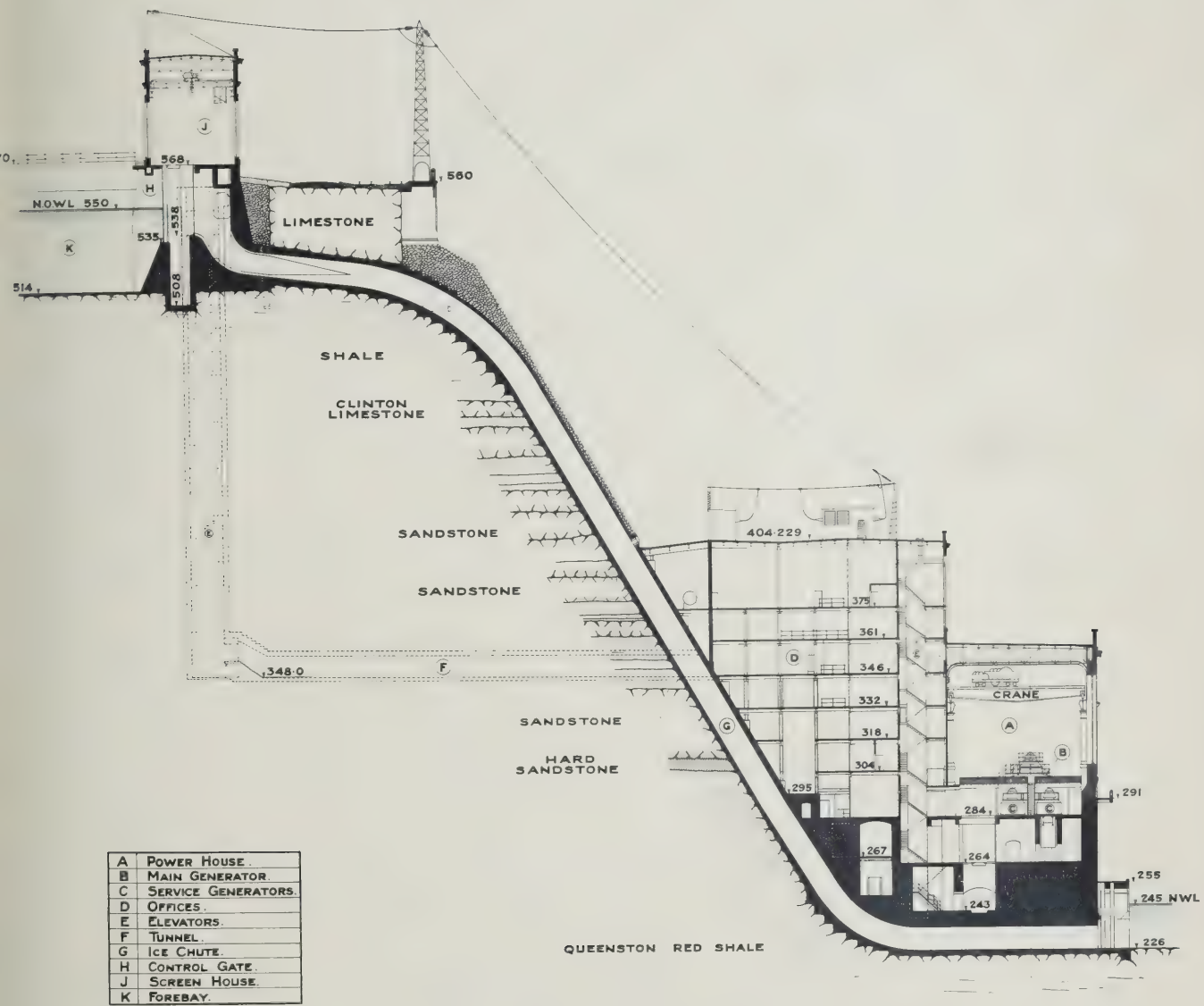
Section Through Screen House Service Penstock & Power House

Scale as Indicated

Toronto, June 7th. 1922 Made by H.B.A. Checked by J.C.H.

Walter J. Francis, C.E.,

Consulting Engineer



A	Power House.
B	Main Generator.
C	Service Generators.
D	Offices.
E	Elevators.
F	Tunnel.
G	Ice Chute.
H	Control Gate.
J	Screen House.
K	Forebay.

Elevations Referred To H.E.P.C. Datum Shown Thus:- 291

Scale of Feet.

Hydro-Electric Inquiry Commission

W. D. Gregory - Chairman

Queenston-Chippawa Power Development

Section Through Screen House Ice Chute and Power House

Scale as Indicated

Toronto, June 15th 1922. Made by H.P.A. Checked by J.L.H.

Walter J. Francis, C.E.,

Consulting Engineer

is primarily the containing structure of the main units, has its top surface at Elevation 297.25 while the bottom is founded in the solid rock which has been excavated down to about Elevation 224.0 for that purpose.

The substructure forms the anchorage at the bottom of all the penstocks, and is also arranged as the foundation of all the turbines and the electrical machines. Along the river side, the substructure extends in the form of piers arched over with a floor constituting a railway passage. Arrangements have also been made in the design whereby the railway cars may be taken into the power house. The substructure is of concrete throughout, reinforced with steel where special stresses occur. WJF. E-88.

By referring to a series of photographs given on pages E-60 to E-66 of our Consulting Engineer's report entitled "General Description", a comprehensive idea of the nature and extent of the power house construction and particularly of the substructure may be obtained.

The superstructure is built of steel, concrete, reinforced concrete and terra cotta finished in Portland cement. It covers the substructure and encloses the whole of the space up to the face of the cliff to the top of the principal roof which is at Elevation 404.0. The portion over the main generating units rises in one clear story, and contains two cranes each with a lifting capacity of 150 tons so arranged as to be able to handle 300 tons when working together. The northerly end of the superstructure contains the high tension transformers, switches and bus-bars, located generally on the three principal floor levels. WJF. E-89

The power house is undoubtedly the most interesting part of the whole development so we include as a frontispiece to this report a composite photograph showing the structure as it will appear when finally completed. Also as a frontispiece we include another photograph showing the progress on the power house to October 31st, 1923, and the relationship its location bears to the Niagara River.

Turbines

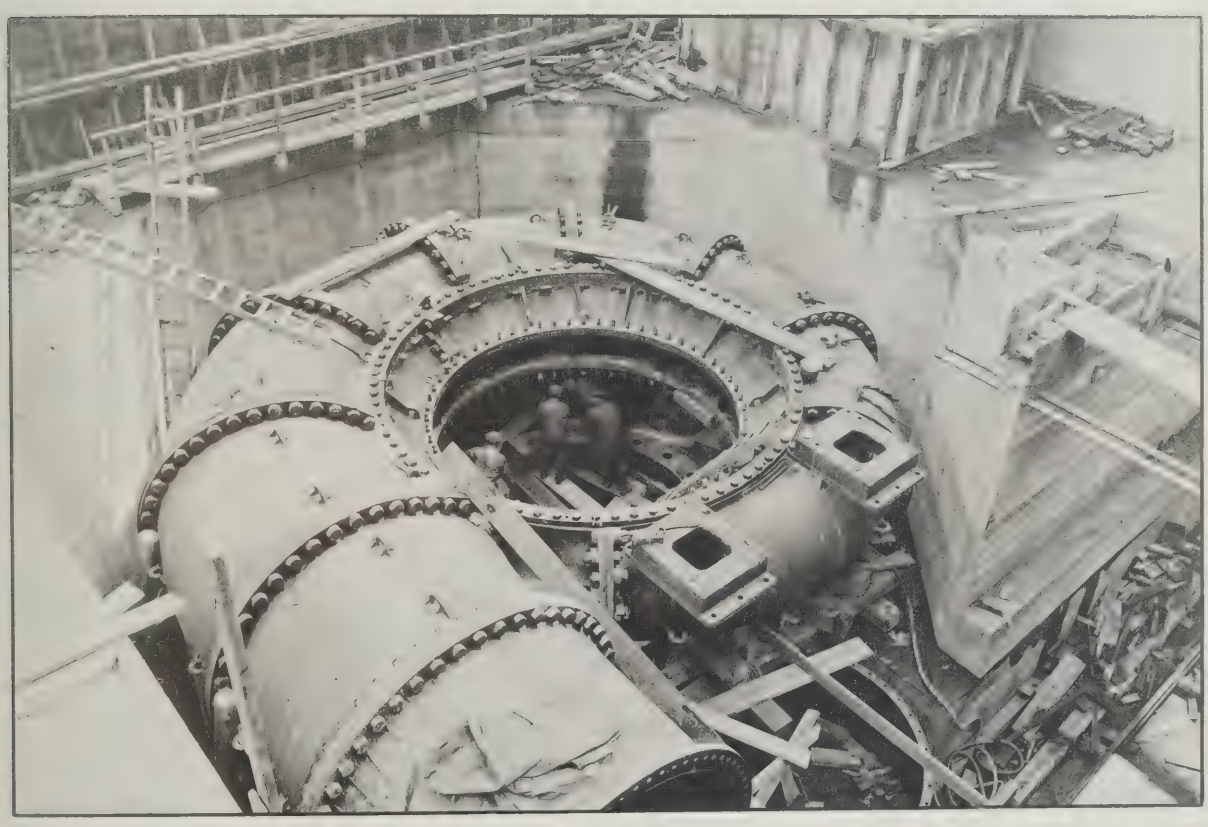
The main unit turbines Nos. 1 to 5, inclusive, are of the vertical shaft, spiral case, single runner, Francis type, operating at 187½ revolutions per minute with a nominal brake horse-power of 58,000 under 305 feet head. An excellent idea of the magnitude of these turbines may be obtained by referring to page 56 which is a photograph showing the scroll case of No. 2 turbine taken during erection.

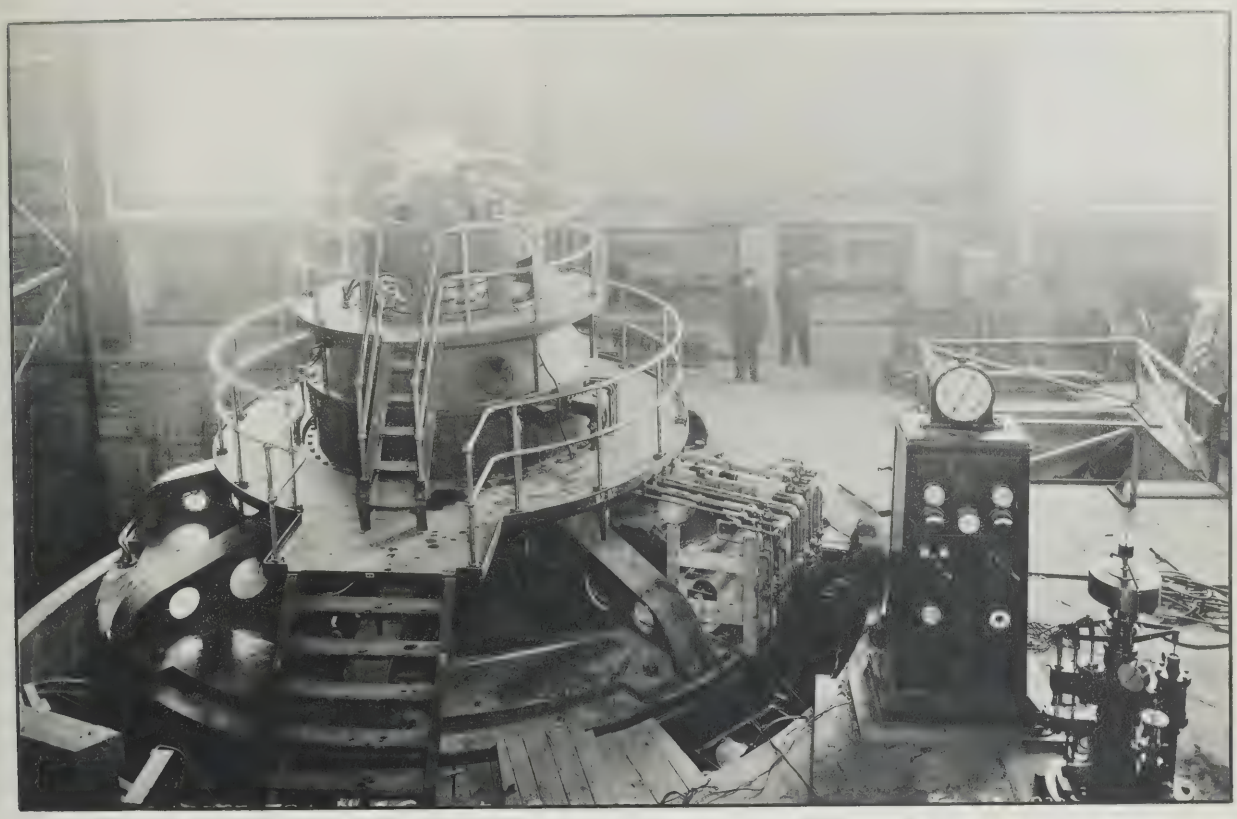
WJP.
E-67

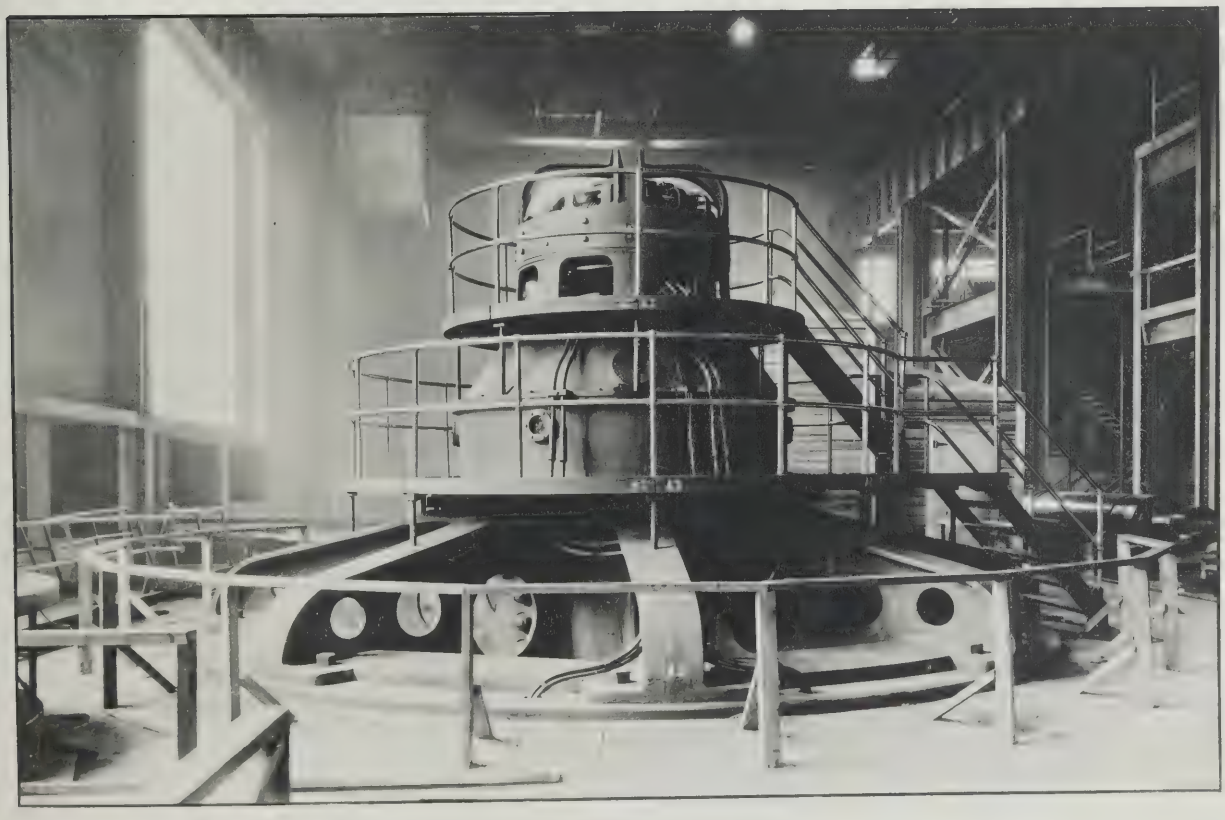
The remaining turbines to be installed for Units 6 to 9, inclusive, will be generally of the same character as for Units 1 to 5.

Generators

The five main generators now installed are each rated at 45,000 kv.a. 80% power factor, 12,000 volts, three-phase, 25 cycles, at 187½ revolutions per minute. They are of the vertical type, with direct-connected, shunt-field, commutating-pole, 250-volt, 150-k.w. exciter. The overall diameter of the main generators is 25 feet, the diameter of the rotor over the pole faces being approximately 18 feet. We include herewith as page 57 two photographs, the top photograph showing the top of Generator No. 2 together with the control pedestal and the governor, while the lower picture shows the top of Generator No. 1.





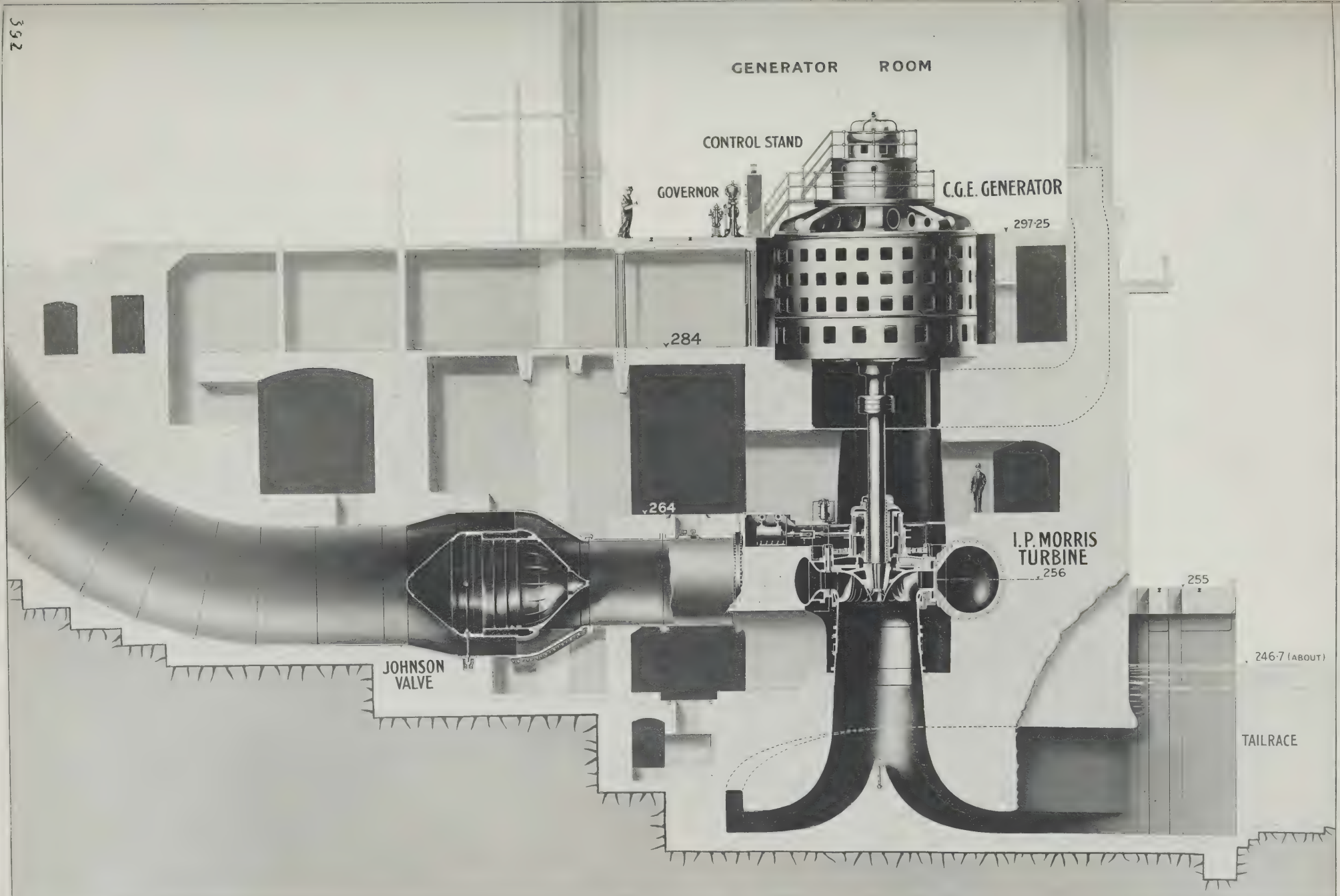


We include herewith as page 59 a wash drawing which shows the relation of all the principal parts of a main unit. To the extreme left of the picture at Elevation 256.0 will be noted the Johnson valve which controls the flow of water from the penstock to the turbine, which is shown at the same elevation on the centre line of the picture. After the water passes through the turbine, it escapes through the vertical opening immediately below the turbine which is known as the draft tube and is finally released into the Niagara River through the tailrace, which is shown at the extreme lower right hand of the photograph. The generating unit is at the top centre of the photograph connected to the turbine by a steel shaft. An idea of the magnitude of a complete main unit will be obtained by comparing the size of the figure of the man shown on the drawing with the various parts which comprise the main unit.

Miscellaneous Equipment

The power house contains many other pieces of equipment essential to the operation of the whole plant. We have referred to the service penstock in the previous pages of this report and it is for the purpose of operating two turbines which in turn are connected to two generators which are each rated at 2,200 kv.a. These are known as the service generators and are installed for the purpose of pumping, ventilating, lighting and other similar purposes.

The auxiliary source of excitation of the main units consists of a motor generator set designed to carry the excitation of any one of the generators. These motor generator sets are driven from the service units.


GENERATOR ROOM
CONTROL STAND
GOVERNOR
C.G.E. GENERATOR
297·25
284
264
I.P. MORRIS TURBINE
256
255
246·7 (ABOUT)
JOHNSON VALVE
TAILRACE

The power house also contains the electrical equipment which consists generally of the low tension switching system, the transformers, and the high tension switching system leading to the transmission lines. The installation includes the necessary circuit breakers, relay protectors, reactors and lightning arrestors.

The power house also contains a complete drainage system with electrically operated pumps, an elevator serving all floors, an automatic elevator near the control room for the use of operators, shop equipment, erection and assembly equipment, offices, operators' quarters, a hospital room, a kitchen and a dining room. These services are included in the southerly 75 feet of the building and the duplication of these is contemplated in the northerly end of the building for the ultimate installation.

WJF.
E-78.

Tailrace

As the draft tubes discharge directly into the Niagara River, the tailrace of the plant is reduced to the minimum, the side of the power house being at the water's edge. The tailrace excavation consisted essentially of removing material forming the temporary dam for the power house excavation.

WJF.
E-78

Section 13

RIGHT - OF - WAY

Sufficient area of lands was purchased by the Commission to provide not only a right-of-way for the canal itself, but also for disposal areas, for the power house, for construction railways and so forth. It is stated that in order to avoid separation damages in the case of farms,

The power house also contains the electrical equipment which
operates generally at the low tension switching system. The transformers
and the high tension external circuit leading to the transmission line-
conductors and lightning arrestors.

The installation includes the necessary standby reserve, relay switchgear,
meters, a station and a direct room. These chambers are included in the
complement in the workshop. Spare chambers are included in the main-
tenance bay

whole properties were purchased in many instances. In addition it would appear that the Commission had in mind the construction of another development at the time the right-of-way was purchased, and for this reason purchased considerably more land than was required. The total area of land involved in the purchase is approximately 3,540 acres and the greater part of the land required in the Development or for disposal purposes was either cultivated or used for fruit-growing purposes.

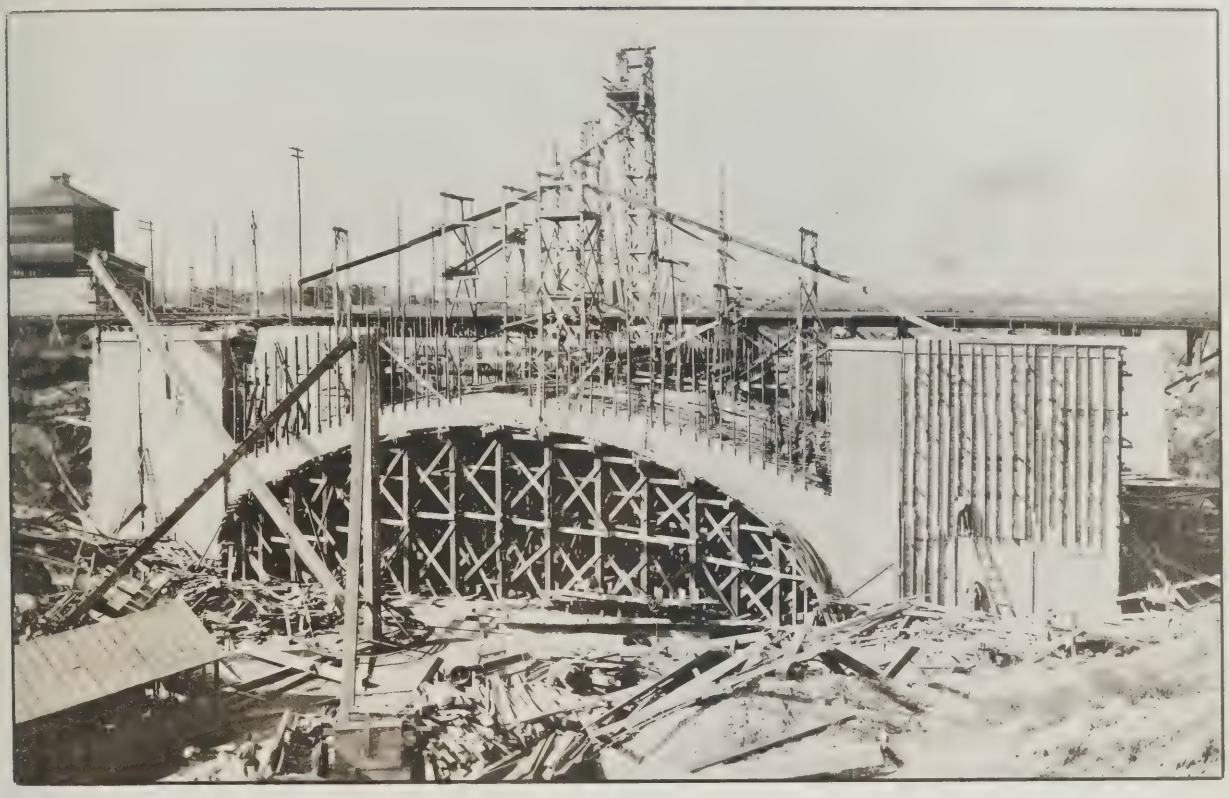
Section 14

BRIDGES AND CROSSINGS

Provision has been duly made for suitable bridges across the canal at all points where necessary for the accommodation of highway or railway traffic. There are eight highway bridges and five railway crossings. These are all described in our Consulting Engineer's report entitled "Chapter E - General Description", but for purposes of illustration we include herewith pages 62, 63, 64 and 65 illustrating the more important structures that were required in this connection.

In addition to the bridges described above, there are eight high-tension power line crossings and four low-tension power line crossings. Of the eight high-tension crossings, four belong to The Ontario Power Company, one to the Toronto Power Company, two to the Canadian Niagara Power Company and one to the Commission. The four low-tension lines are the property of The Ontario Power Company.

WJF.
E-88



PART IV - CONSTRUCTION PROCEDURE

Section 15

G E N E R A L

The construction of the Development was carried out under two methods of procedure, namely by contracts and by force account. Taking the elements of the works in the general order of their occurrence in the Development, the procedure was for (a) the intake, by force account up to April, 1922, and by contract work for the completion since that time; (b) the Welland River, by force account with plant purchased or rented up to the Spring of 1922, when a contract was let for dredging; (c) the canal, by force account throughout; (d) the forebay, by force account throughout; (e) the screen house, by force account with a number of separate contracts for the steel work of the superstructure, the windows, the gates and the racks; (f) the penstocks, by force account for excavation and concrete work, with a contract for the fabrication and erection of the steel work; (g) the power house, by force account with contracts for Johnson valves, the turbines, the generators, the transformers, the switches, the cranes and the miscellaneous equipment. The tailrace excavation was carried out by force account. The power house railway, which is essentially a part of the permanent equipment of the plant, was also constructed by force account. WJF. G-1.

Our Consulting Engineer in his report entitled "Contract Work and Other Construction Procedure" sets forth in detail the manner in which the various works were carried on. Sections 16 to 20 of this report deal with the work as executed by the Commission itself, and the equipment employed therein, while Section 21 deals generally with all work executed under private contract.

Unit 19 - Constructing Shelves

Lesson 19

C A R D S

The construction of the Periodicals was carried out under the methods of pioneers, namely by constructs and by those methods. Taking the elements of the woods in the general order of their construction in the Periodicals, the procedure was for [a] the frames, by first making to April, 1823, and by contract with for the complaints since this time; [b] the resting floor, by those accepts with floor information to resting on to the Spring of 1823, when a contract was let the strengths; [c] the cover, by first wrong floor, by first wrong accepted information; [d] the shelves, by first wrong accepted information; [e] the narrow bands, by first accepted with a number of separate contracts for the steel ends of the stanchions, the shelves. The parts and the ends; [f] the partitions, by first wrong accepted information; [g] the panels, by first wrong accepted information; [h] the panic bands, by first accepted with contracts for different rates, with a contract for the fabrication and bracing of the steel ends; the supports, the crossmembers, the uprights. The entire and the miscellaneous equipment. The existing construction was modified 312. by first contract. The first bands rolled, which is essentially a pair of the permanent uprights of the plate, was also manufactured by first wrong accepted. 3-9.

Our Committee Decision to this report entitled "Contract with the original Construction Procedure" note light in detail the manner in which the various works were carried on. Inasmuch it as is of this report deal with the work as executed by the Commission itself, and the original methods, while varying it would generally with all work executed

Section 16

EXCAVATION - CANAL

The question of the type of plant to be used in connection with the work was the subject of much study on the part of the engineers of the Commission, particularly Mr. Acres and Mr. Goodwin. In the report of Mr. Acres, known as Report on Project No. 2, under date of December 26th, 1917, the following statement appears:

"A careful study of construction methods in connection with the excavation of earth and rock in the canal was necessary by reason of certain existing conditions which would have a vital influence upon excavation cost. These conditions were, first, the availability of cheap electric power for operating construction plant; second, the large quantities of earth and rock to be removed, which made it possible to consider the use of excavating machinery of the heaviest type and largest capacity obtainable; and third, the unusually good facilities available for the disposal of spoil, within short hauling distance, along the crest of the Niagara escarpment.

"Having the above conditions in mind, the Commission's Engineers spent several months in collecting and studying data in connection with the type of construction plant required. The operation of electric and steam driven excavating machinery was witnessed and studied in various parts of Canada and the United States and a large amount of information with reference to output, operating cost, working conditions, etc., was obtained and carefully analyzed.

"The result of this investigation was, that in January, 1917, when market conditions indicated that any further delay in the purchase of the plant would result in prohibitive prices and practically impossible delivery dates, the Commission's Engineers were immediately able to recommend for purchase the type of plant best suited for carrying on the projected work.

"Practically all of the plant so purchased is now on the ground and a portion of it is in actual operation."

Our Consulting Engineer says that:

"The engineers of the Hydro-Electric Power Commission decided that the excavation of the dry material in the Canal could best be done by specially built electrically-driven shovels, aided by a number of shovels of the ordinary size and type. Following the removal of the overburden of earth, the rock excavation was to be done by the same shovel plant. It was decided that the sides of the rock canal were to be cut down by channelling machines, and the body of the rock was to be drilled and blasted.

"The earth and rock spoil were to be removed by means of a specially constructed railway system. The sub-aqueous work was to be done by dredging." WJF. H-97

As a result of the adoption of this general programme, the engineers of the Commission purchased from time to time a total of thirteen shovels, six of which were driven by steam and seven by electrical energy, the bucket capacity varying between 7/8 of a cubic yard and 6 cubic yards. They also purchased twenty channellers, forty-four marine drills, sixty-three tripod drills, fifteen drifters, ninety hammer drills and one well drill, together with all the necessary accessories therefor. In connection with the sub-aqueous work the necessary plant was rented. For purposes of convenience the following table gives the principal items of excavation plant used for the canal together with dates of purchase and the cost.

List of Shovels

Unit No.	Motive Power	Weight in Tons	Bucket Capacity in Cu. Yds.	Make	Model Number	Date of Purchase	Cost
1	Electric	332	8	Bucyrus	225-B	Mar.28/17	$88,000
2	Electric	332	8	Bucyrus	225-B	Mar.28/17	88,000
3	Electric	118	4-1/2	Bucyrus	103-C	Mar.28/17	43,865
4	Electric	118	4-1/2	Bucyrus	103-C	Mar.28/17	43,865
5	Steam	30	7/8	Bucyrus	18-B	Mar.28/17	10,805
6	Electric	30	7/8	Bucyrus	18-B	Mar.28/17	15,732
7	Steam	65	2-1/2	Bucyrus	45	Sep.13/17	9,000
8	Electric	332	8	Bucyrus	225-B	July 6/18	152,000
9	Electric	118	4-1/2	Bucyrus	103-C	July 6/18	73,785
10	Steam	35	1-1/4	Bucyrus	35-B	May 10/19	23,750
11	Steam	275	8	Marion	300	July12/20	142,350
12	Steam	332	8	Bucyrus	225-B	Aug.14/20	138,072
13	Ditcher	12	1/2	Keystone	4	Oct.14/19	5,900
14	Steam	93	2-1/2	Marion	60	Nov. 1/20	17,128

List of Other Excavating Plant

2 Jordan Spreaders, 100,000 lbs. capacity,with equipment.
1 Bucyrus Spreader, 142,320 lbs. capacity,with equipment.
1 Jordan Spreader, 80,000 lbs. capacity,with equipment.
20 Sullivan Channellers.
44 Marine Drills.
68 Tripod Drills.
15 Drifter Drills.
90 Hammer Drills.
1 Well Drill.

WJF.
H-98

The manner in which actual operations were carried on and a general idea of the magnitude of the work may be best gained by observing typical photographs of various pieces of equipment actually on the work. For this purpose, therefore, the next few pages of this report consist largely of photographs with descriptive matter illustrating various pieces of equipment in action.

List of Figures

Fig. No.	Description	Page
1	Elevation and plan of the Bridge	12
2	Foundation details	13
3	Cross-section of the Bridge	14
4	Erection scheme	15
5	Traffic diagram	16
6	Elevation and plan of the Bridge	17
7	Foundation details	18
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10	Traffic diagram	21
11	Elevation and plan of the Bridge	22
12	Foundation details	23
13	Cross-section of the Bridge	24
14	Erection scheme	25
15	Traffic diagram	26

The upper photograph on page 71 shows one of the large electric shovels, Shovel No. 1, in operation near Bowman's Gully, in August 1918. The shovel is in the act of loading a car at a high elevation. In passing it is interesting to note the stratification exposed by the shovel, the work track of which is about 70 feet below the natural surface on which the vegetation may be seen.

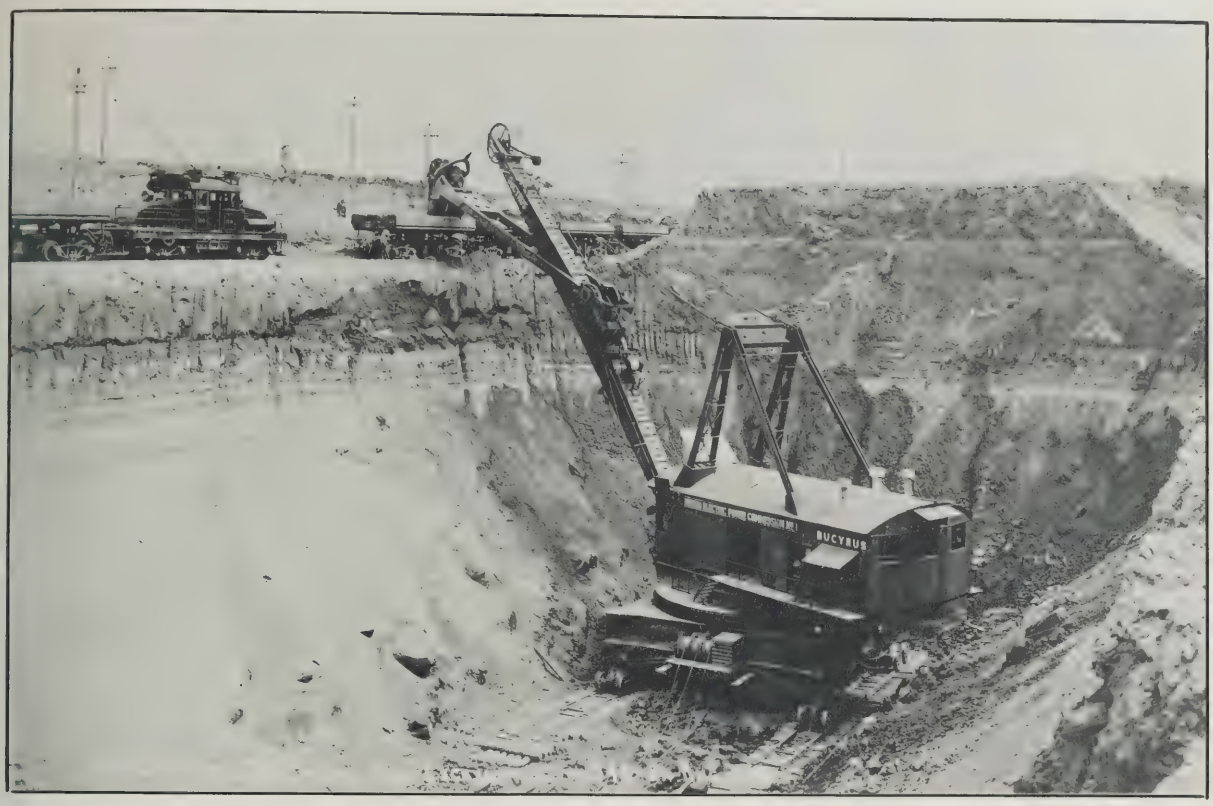
The lower photograph on the same page shows large steam shovel No. 11, loading earth into a car at a high elevation.

The upper picture on page 72 shows a group of channelling machines at work on the rock surface. It will be noted that the earth overburden has been entirely removed and the underlying rock surface exposed. These channelling machines were employed by the Commission before it was decided to line the canal with concrete; and were used for the purpose of giving a relatively smooth surface to the rock faces of the water channel.

The lower picture on the same page shows the Keystone ditcher digging a drainage ditch.

Another very interesting feature of the construction work was the drilling carried on in connection with the blasting operations in the rock work. The two photographs on page 73 give two views of batteries of marine drills. In the upper picture a battery of eight is shown working in the canal near the forebay, and the lower shows a battery of thirteen in the cut near Lundys Lane.

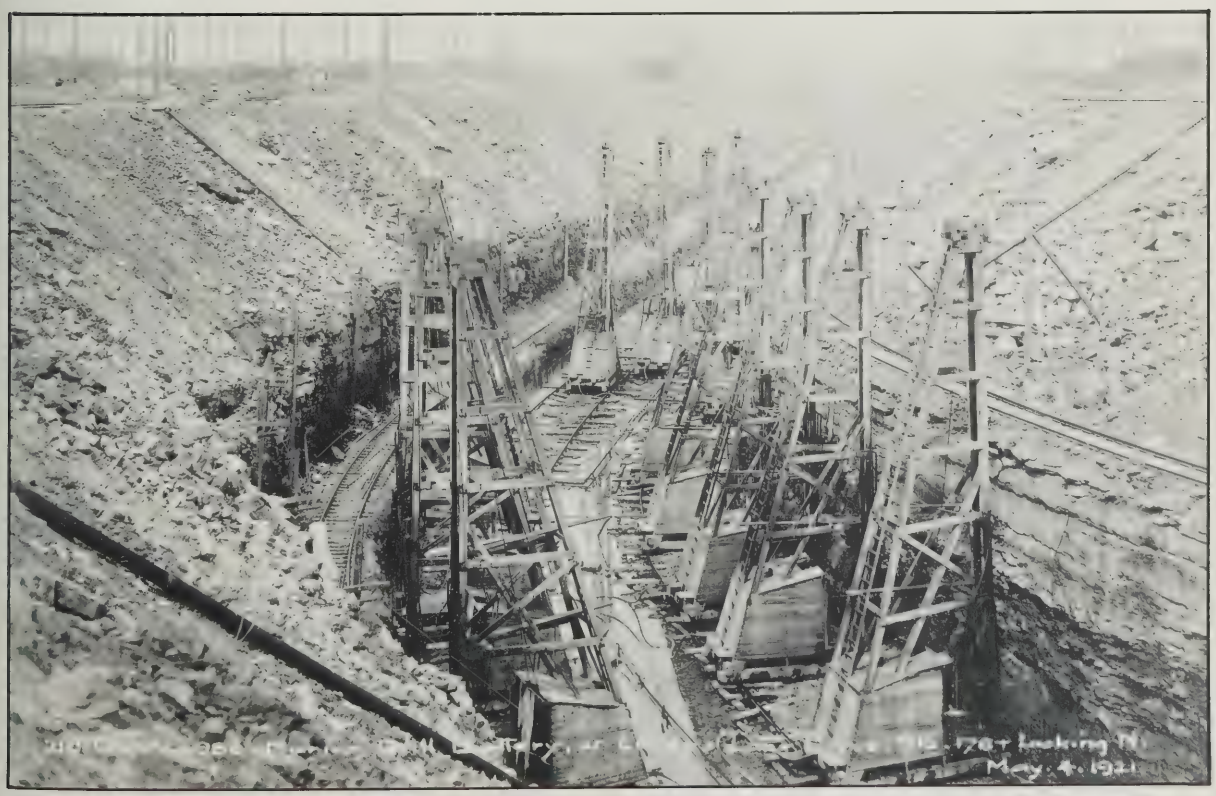
These illustrations give a general idea of the major equipment units used on the work.


BUCYRUS


11


210-C
Feb. 6, 19


210-CANAL-


May. 4. 1921

General Dimensions of the Large Shovels

Seeing that a number of the shovels used on this work were the largest ever built and that their use was without precedent at the time the Commission decided upon their adoption, a brief description of their general dimensions is now given.

The first three large shovels purchased are known as 225-B revolving Bucyrus shovels, equipped with an 80-foot boom, and a 58-foot dipper for normal operations, and having a 90-foot boom for exceptionally high levels. The weight of each shovel is 332 tons. Under normal conditions a 5-cubic yard dipper is used for rock excavation, and an 8-cubic yard dipper for earth. Equipped with the auxiliary parts these shovels load cars standing on a track 70 feet above the track of the shovel, dig a cut with a bottom width of 120 feet and load cars at the above height 88 feet sideways from the centre of the shovel. The large shovels are mounted on two parallel tracks each of 56-inch gauge, the distance from centre to centre of tracks being 30 feet. These shovels were operated by electric motors, instead of by steam as is the usual custom.

WJF.
H-108

The operation of the large shovels was a most important factor in the construction of this Development, and we will deal with their working capacity later in this report. At this point it may be noted that the engineers of the Commission state that the working capacity of each of these shovels as given by the manufacturers is 5,000 cubic yards of earth or 3,000 cubic yards of rock per day of ten hours. These figures were used by them as a basis when preparing Estimate No. 2. As will be noted from the list of equipment previously given, shovels Nos. 1, 2 and 8

were of this type. As the work progressed, it was decided to purchase two additional shovels but it was impossible to procure others of the same type. In July, 1920, the Commission ordered what is known as Shovel No. 11, being a Marion steam shovel, Type No. 300, weighing 275 tons, and having the other characteristics comparable with shovels Nos. 1, 2 and 8. Again on August 14th, 1920, the Commission purchased Bucyrus steam shovel No. 12 similar in all respects to Nos. 1, 2 and 8, excepting that the motive power was steam.

Other Shovels

Shovels Nos. 3, 4 and 9 were next in size to the largest being Bucyrus model No. 103-C, weighing 118 tons, electrically driven and equipped with a 3-1/2 cubic yard bucket for rock and a 4-1/2 cubic yard bucket for earth. The engineers of the Commission state that the capacity of these shovels as given by the makers is 3,500 cubic yards of earth or 2,000 cubic yards of rock per day of ten hours.

Two other shovels, Nos. 7 and 14 had bucket capacities of 2-1/2 cubic yards. The other shovels were smaller in size and of the usual type, well-known to those familiar with construction work.

Under the original project, according to Estimate No. 2, the Commission contemplated buying only two of the 225-B shovels and two of the 103-C shovels. It was stated by Mr. Acres that he estimated the two 225-B shovels would handle about 40% of the earth excavation and 80% or 90% of the rock excavation, while the two 103-C shovels were to excavate the remainder scheduled for the four machines. WJF. M-109 WJF. M-42

The amount of equipment actually used on the work was greatly in excess of the amount originally contemplated, and the Commission states that this increased amount was necessary because of changes in design which caused an increase in quantities, and because of the delay in getting the work started, which necessitated a rush schedule. No doubt these were reasons in part for the increase, but a great factor was the failure of the shovels to excavate as much as the engineers of the Commission expected.

This matter will be dealt with in detail in a later section of this report. The actual performance of the equipment is given in our Consulting Engineer's report, Chapter H, and progress diagrams are included as pages H-131 to H-140 of the same document. These charts form a graphic picture of the progress of the whole work and show the exact location of each shovel during the entire construction period.

Sub-aqueous Excavation

The suction dredge "Cyclone" excavated a total of about 1,100,000 cubic yards between the Welland River and Station 55. The manner of making the excavation may be clearly seen by reference to the photograph on page 78 which shows the dredge in operation shortly before it completed its task. It discharged the material on disposal areas located on the westerly side of the canal.

WJF.
H-147

The dredge operated for 204 working days between December 10th, 1920, and September 3rd, 1921.

The "Cyclone" was not purchased by the Commission, but was rented from the Toronto Harbor Commissioners for a total lump sum price of $250,000.

By the terms of the contract, the Harbor Commission delivered the "Cyclone" to the Commission at Toronto on the 29th of November, 1920, complete with all equipment, and the Commission agreed to return the dredge with its equipment on or before the 15th day of September, 1921. In addition the Commission undertook to insure the dredge against fire and marine risks in the sum of $1,000,000 and the pontoons accompanying it in the sum of $100,000, the Commission to bear the cost of the premiums.

By a supplementary agreement, the Commission undertook to pay the Harbor Commissioners the sum of $850,000 in case of loss of the dredge on the trip to and from Chippawa in lieu of providing the before-mentioned insurance. The "Cyclone" after finishing its work on September 3rd, 1921, was duly returned to the Harbor Commissioners at Toronto.

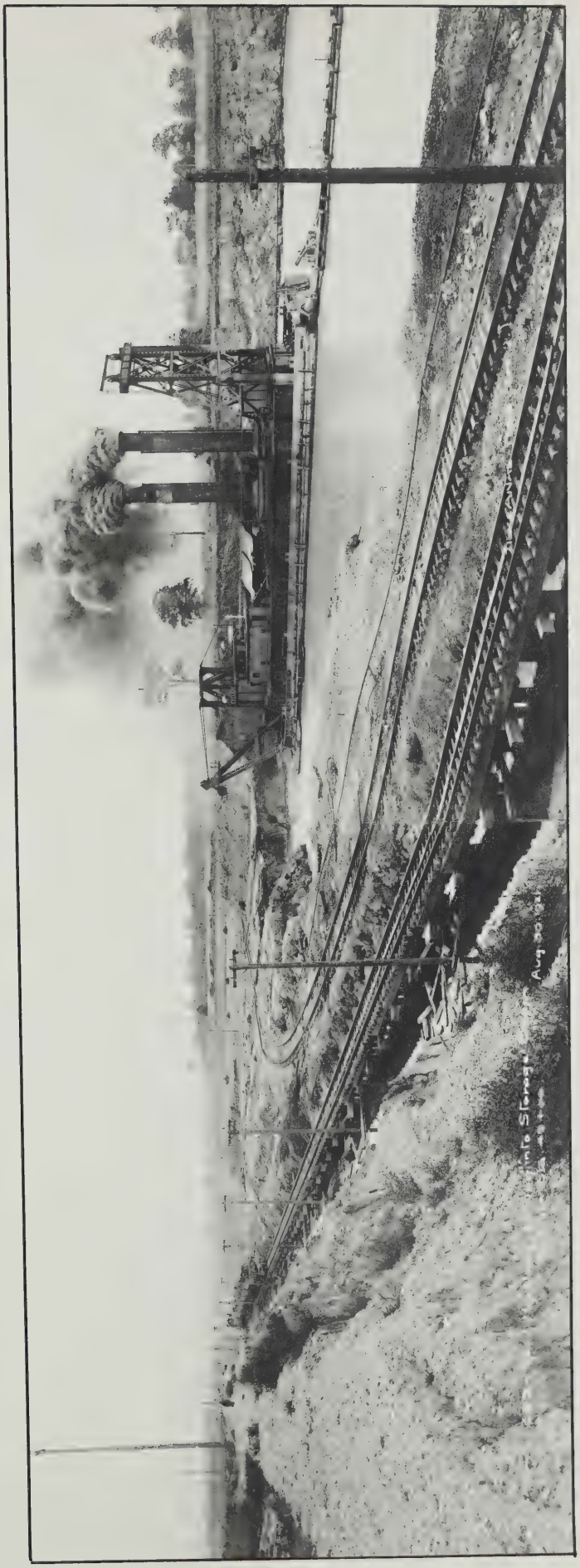
On the completion of the excavation by the dredge "Cyclone", the Commission entered into a contract with John E. Russell for the excavation of 30,000 cubic yards of sub-aqueous earth work at the junction between the Welland River and the entrance to the canal, and at the commencement of the rock section, at a price of 70 cents per cubic yard. The work was done by Mr. Russell with the dredge "Niagara" (since called the "Hennessy"). Mr. Russell provided his own plant for the work.

WJF.
H-152

Section 17

EXCAVATION - INTAKE, WELLAND RIVER, FOREBAY, SCREEN HOUSE AND POWER HOUSE

The excavation work in the intake and in the Welland River was entirely in earth, and, as carried out up to March 31st, 1922, involved methods different from those used in the earth and rock excavation in the canal. This was sub-aqueous excavation.



The forebay excavation was done in the same way as the canal excavation and in the dry and with the same plant. The gate-house excavation was carried out in the same way as the forebay excavation.

The power house excavation was also done in the dry by means of the shovels which had worked in the canal.

The rock faces of the walls of the forebay excavation were not lined with concrete as in the case of the canal, but were finished with gunite over all the faces of the softer rock that had been exposed. The floor of the forebay was left as excavated. The excavation for the concrete envelope of the penstocks was carefully cut down by hand and light blasting.

WJF.
H-154

The Intake

It was originally intended to construct the intake in the usual form of a submerged boom, but in May, 1918, the engineers of the Commission decided to adopt a design of intake which would in their judgment minimize the danger of shutting down of the power plant through ice trouble, this decision being arrived at as a result of special studies and experiments.

WJF.
H-154

The site of the intake at the junction of the Welland River with the Niagara River and its relation to the principal topographical features may be clearly seen by referring to the photograph on page 80. The adoption of this design of intake has an indirect bearing on the construction plant utilized for this part of the work.

The method used for the excavation of the site of the intake was carried out by the dipper dredge "Charles Boome". The sub-aqueous

portion of the site was covered by about 12 feet of water, and the rock surface carried an overburden of about 16 feet of boulder clay, which increased in density and hardness near the rock surface. In order to provide a dry site for the erection of the concrete intake structure, a temporary dam was built from the north-easterly side of Hog Island outside the line of the structure and joining with the westerly shore of the river. The dam was built by driving a line of steel sheet piling down the centre of the chosen location, and depositing the earth spoil from the dredging on either side of the sheet piling. The construction of the dam may be seen by reference to the photographs included as page 82.

WJP. H-161

An idea of the magnitude of this piece of work may be had by referring to our Consulting Engineer's report entitled "Analysis of Expenditures", page K-64, where it is found that the whole intake work cost $965,549.01 of which amount the sheet piling and the earth in the temporary dam cost approximately $500,000.00. The greater portion of the spoil from the intake site was deposited in the Niagara River immediately down stream from Hog Island. It is stated that from this source over 752,000 yards were deposited at this location.

The spoil was transported from the excavating plant to its destination in bottom-dumping scows. A small amount of spoil was also transported and dumped on the northerly side of Navy Island. The work of clearing off the rock on the site of the intake was completed in 1921 and on May 5th, 1922, a contract was let to Messrs. Tomlinson, Macaw and McDonald for the building of the concrete structure of the intake with the exception of some dredging work in the Welland River and the removal of the earth dam on the

WJP. H-168

intake.

We have already described the intake structure in a general way, but we include on page 84 a plan showing the work included in the Tomlinson, Macaw and McDonald contract. The contractors finished all of the work with the exception of the removal of the piling practically on time, the removal of the piling being completed in March, 1923.

The removal of the earthwork of the temporary dam was let to the C. S. Boone Dredging and Construction Co. at the rate of 65¢ per cubic yard for a limited amount of winter work and 45¢ per cubic yard for the bulk of the yardage to be removed during the summer months. WJF. H-168

The Welland River

The excavation work on the Welland River up to March 31st, 1922, was all sub-aqueous, and was done by the dipper dredge "Charles Boone", the suction dredge "Cyclone", the suction dredge "Hennessy", formerly called the "Niagara", and a Lidgerwood cableway. For reference we include herewith as pages 85 and 86, plans showing the nature and extent of the work on this section of the Development, the portions coloured red showing the various disposal areas used for the disposition of spoil from the equipment above mentioned. WJF. H-170

The Lidgerwood cableway used by the Commission commenced work at Station 78+00 on May 13th, 1918, and completed its work on July 2nd, 1921. This piece of equipment may be best illustrated by referring to

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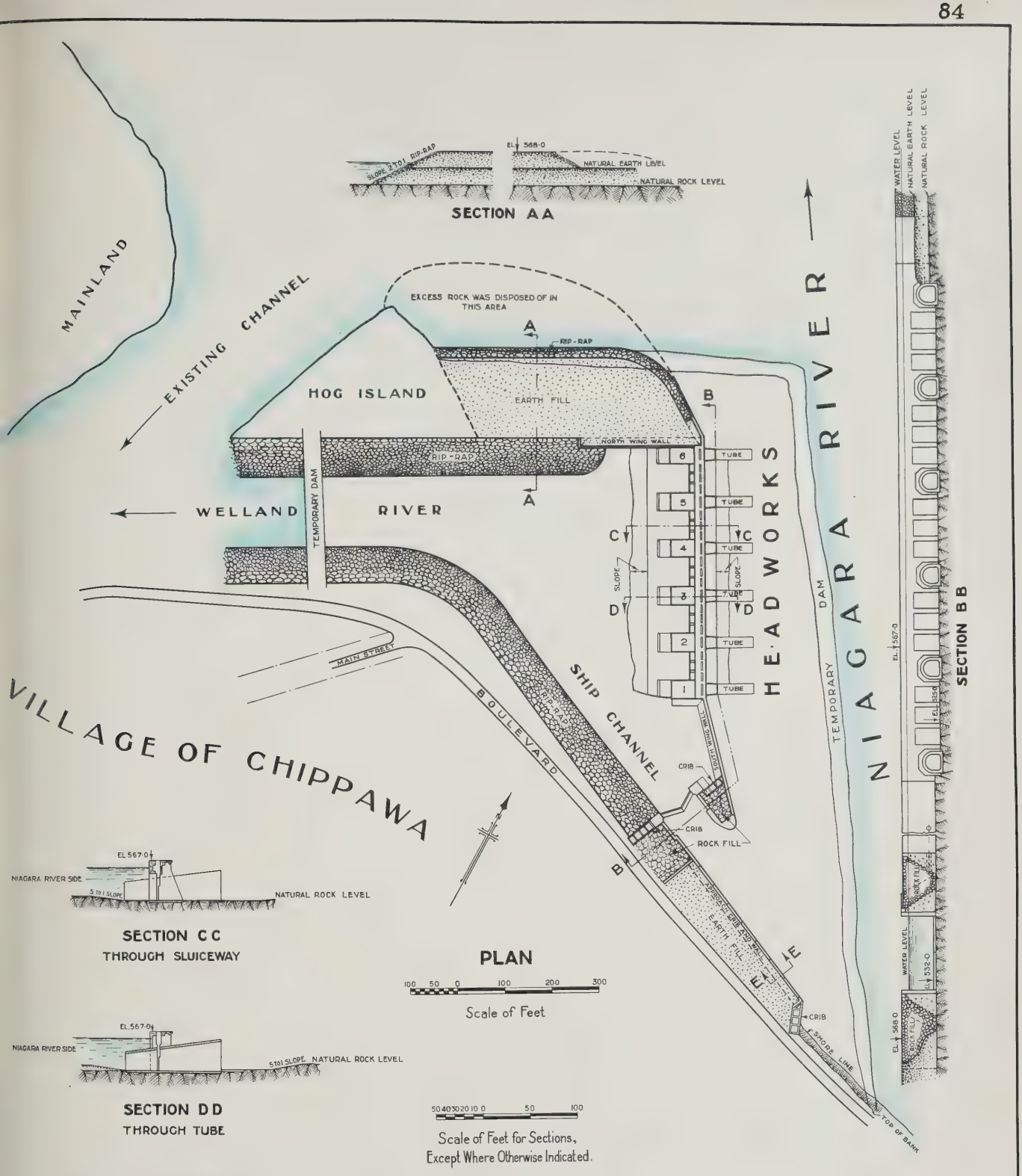


HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

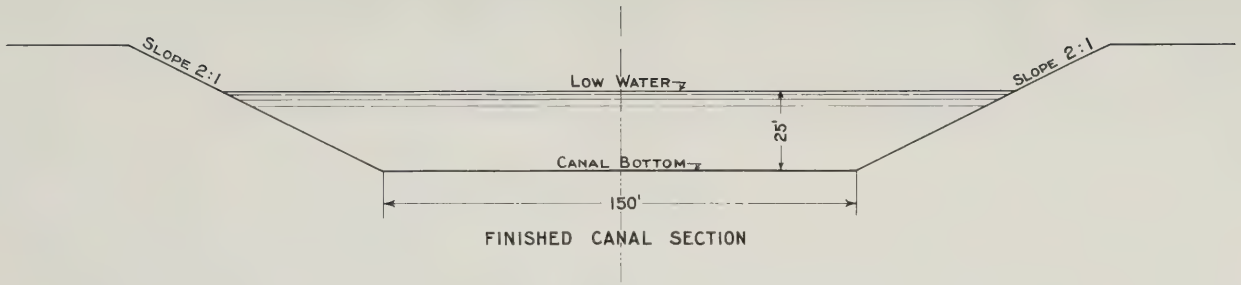
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

GENERAL PLAN OF INTAKE

Toronto, March 29th., 1923. Made by [illegible], Checked by [illegible]

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS



FINISHED CANAL SECTION

NIAGARA RIVER

INT. RY. CO.

HOG ISLAND

INTAKE

SHIP CHANNEL

STA. 20

STA. 30

M.C.R.R.

STA. 50

STA. 60

STA. 70

STA. 80

VILLAGE OF CHIPPAWA

"CHARLES BOONE" DREDGE WORK

Pell's Creek

STA. 90

STREET

MAIN

River

Welland

STA. 100

STA. 110

"D"

ROAD

Lyons Creek

CABLEWAY

CHIPPAWA ST.

CREEK

STANLEY

STA. 120

STA. 130

STA. 140

STA. 150

STA. 160

STA. 170

"D"

"D"

Scale of Feet

500 0 500 1000 1500

WORK DONE BY LIDGERWOOD

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

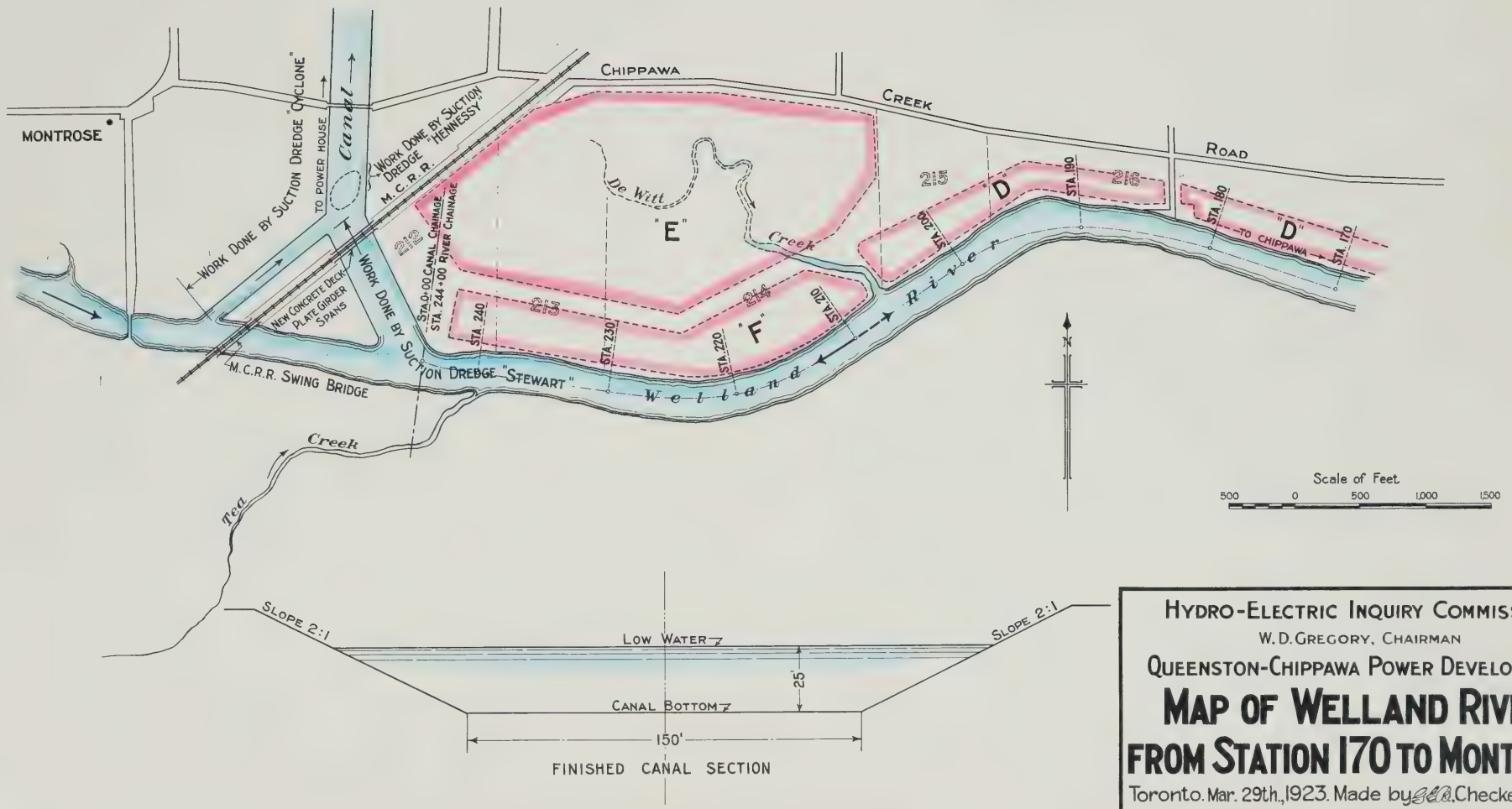
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

MAP OF WELLAND RIVER FROM INTAKE TO STATION 170

Toronto, Mar. 29th, 1923. Made by S.E.D. Checked by W.J.

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS



HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY, CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

MAP OF WELLAND RIVER FROM STATION 170 TO MONTROSE

Toronto. Mar. 29th., 1923. Made by [illegible]. Checked by [illegible]

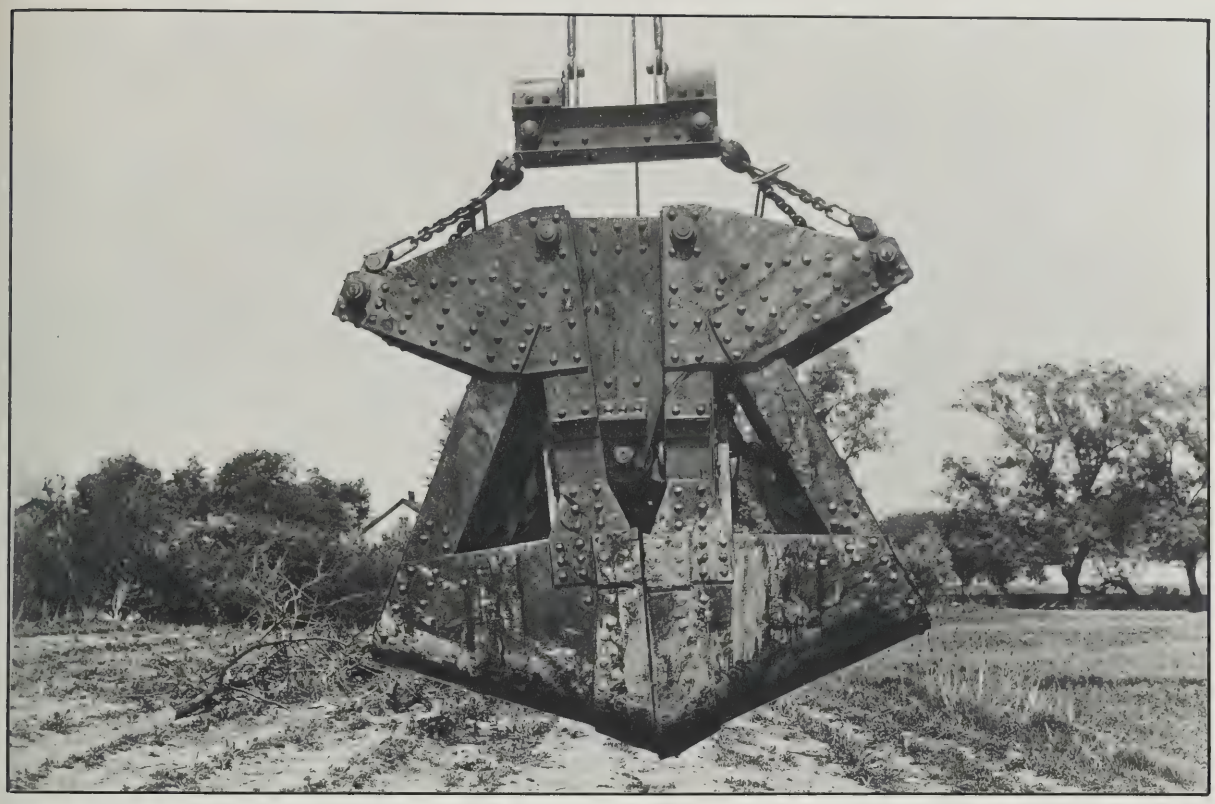
WALTER J. FRANCIS & COMPANY

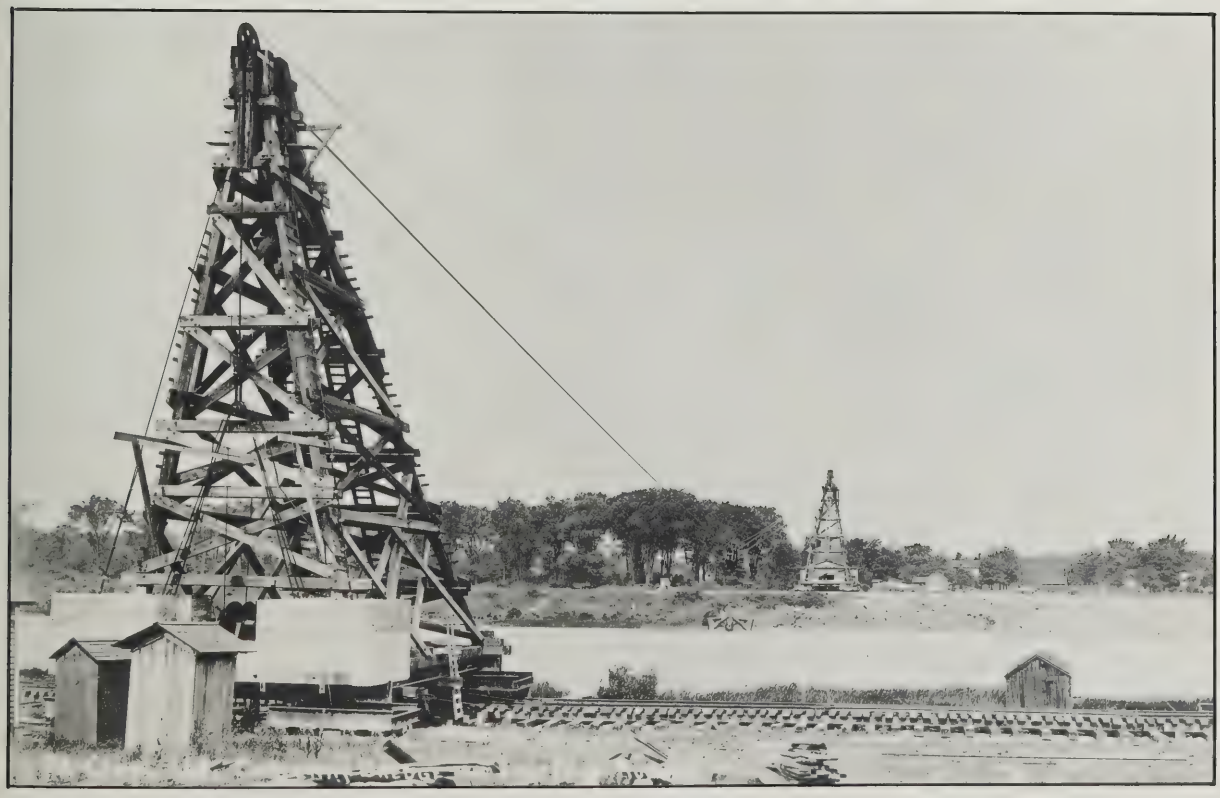
CONSULTING ENGINEERS

the photographs on page 88, the top one of which shows the bucket used which had a capacity of three cubic yards and was worked by electric motors located in the head tower which is seen in the photograph at the bottom of the same page. The total amount of material excavated by the Lidgerwood cableway was 737,062 cubic yards. WJF. H-173

The dredge "Hennessy", a suction dredge with a 14-inch discharge pipe, was used by the Commission to do a small amount of work under contract in connection with the removal of the last 30,000 cubic yards of sub-aqueous excavation in the earth section previous to filling the canal. The "Hennessy" was later used by Messrs. E. G. Leahy & Company, Limited, during the summer of 1922 as part of their plant to commence excavation work pending the completion of the new hydraulic dredge "Stewart". WJF. H-176

On May 22nd, 1922, a contract was entered into between the Commission and Messrs. E. G. Leahy & Company, Limited, of Ottawa, for dredging in the Welland River, whereby the contractor undertook to remove not less than 800,000 cubic yards of earth by the 31st day of December, 1922. It is interesting to note that this contract was let at a unit price varying from 40¢ per cubic yard to 35¢ per cubic yard, the unit price decreasing as the amount of excavation increased. The equipment used by Messrs. Leahy & Company was the specially designed electric suction dredge "Stewart", having a 20-inch discharge pipe, and a minimum estimated capacity of 175,000 cubic yards per month.





The Forebay

In our general description of the plant as completed we have dealt with the forebay. In reference to the construction plant employed thereon it is sufficient to say that the excavation was taken out by the ordinary plant used on the canal section and that the concrete work was executed by ordinary construction plant consisting of a mixing machine, a concrete tower, chutes and concrete buggies.

WJF.
M-178

The Screen House and Power House

As already stated the general excavation for the screen house and power house was carried out by the equipment ordinarily used on other sections of the work, while the excavation for the envelopes for the penstocks was done by close drilling, light blasting and hand trimming. Generally speaking, the face of the cliff was not removed but was merely trimmed and adapted so that it would conform to the relative positions of the screen house and power house and the alignment of the penstocks. For purposes of illustration we include herewith as page 90 a photograph taken shortly after trimming work on the face of the cliff at the power house had been commenced. Near the top of the cliff will be noted the tunnelling work in progress in connection with the penstocks leading from the screen house.

The excavation of the power house pit averaged about thirty feet in depth, and was almost entirely in Queenston red shale. The spoil from the excavation was loaded into cars operating on the power house construction railway which had been previously constructed around the base of the cliff

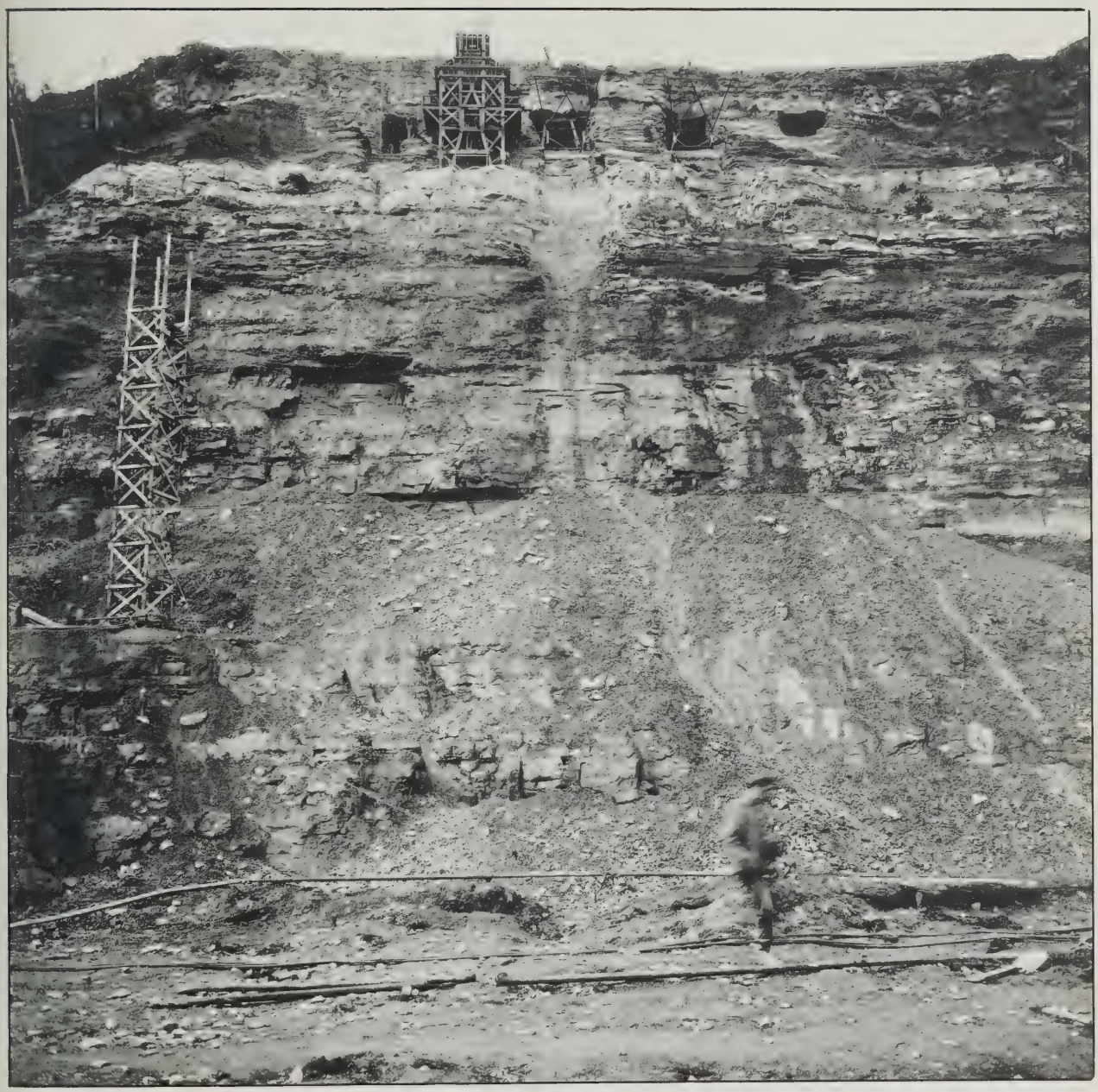
The Factor

In our general investigation of the plant we anticipated no issue
[illegible] with the Control. In reference to the conservation plant workings
[illegible] it is sufficient to say that the conservation was taken out by the
ordinary plant unit on the usual monthly run that the workers were the
[illegible] by ordinary conservation plant investigation it a routine condition, a
conserve issue, unless new necessary inspire.

The Steam Power and Power Plant

As already stated the general assumption for the steam power
and power house was derived not by the equipment originally used or since
[illegible] of the work. [illegible] consideration for the envelope for the pump-
ing was done by close scrutiny, steam pressure and heat [illegible].
Generally speaking, the sum of the utility was not measured was merely
inferred and applied so that it would continue to the [illegible] building if
the steam power key power house and the difference of the [illegible].
purposes of [illegible] as include materials as base of a [illegible] steam
shortly after [illegible] work on the base of the utility of the power house
has been [illegible]. Just the end of the utility will be noted the [illegible]
steam.

The [illegible] of the steam house for examined plant could [illegible]
to help, but not sinner entirely is [illegible] the power house [illegible]
the [illegible] was found just were [illegible] or the power house [illegible]
[illegible] which had been [illegible] without the base at the [illegible]



at the edge of the Niagara River. To provide for the dry excavation a temporary dam was constructed and later removed when the turbine installation had been completed. The removal of this temporary dam, by the use of a travelling derrick with an orange peel bucket, constituted the main operation incident to the excavation of the tailrace.

Section 18

TRANSPORTATION SYSTEM

General

In his reports our Consulting Engineer deals with all transportation facilities employed by the Commission on the work. In referring to the matter generally, Mr. Francis says:

"The transportation of men and material within the district of the Queenston-Chippawa Power Development, which includes an area, say, fourteen miles in length by three miles in width, was accomplished by three principal systems; namely: by automobiles, by water and by a railway system. Speaking generally the automobile system was used by the engineers in conducting the work and for the purpose of distributing stores and merchandise over the works, conveying repair gangs to and from shops to the various major machines where they were needed, delivering goods from the works to the railway stations and vice versa, fire service, ambulance service, and similar instances.

"The water transportation was confined to the works on the Niagara River, the Intake and the Welland River, ...

"The construction railway system was used for handling all material excavated in the dry and for the delivery of carload lots or train lots of construction material, construction plant and permanent machinery.

"No horse-drawn vehicles were used in connection with the work, with the exception of a few waggons in the earlier stages. The greatest number of horses the Hydro-Electric Power Commission had on the work was fifteen teams."

WJF.
H-40

Automobiles

On pages H-42, H-43 and H-44 of our Consulting Engineer's report is shown a list of 88 motor driven vehicles used in connection with the work. A subdivision is as follows:

51 General Service Trucks
6 Tractors
1 Trailer
3 Hospital Service
1 Fire Truck
25 Passenger Cars
1 Motor Cycle

Water Transportation

For the work on the Niagara River, the intake and the Welland River, launches and scows were used for transportation. The details of this transportation will be found in that part of Chapter H referring to the earth and rock excavation of the intake and the Welland River.

Since the filling of the canal in December of 1921, the launch "Malinche" has been used for inspection in traversing the whole length of the canal.

WJP.
H-46

Construction Railway

The construction railway system was the most important of the transportation elements. It comprised in all over seventy miles of standard gauge track and switches and was operated by electric locomotives as well as by steam power. Pages H-47 to H-54 of our Consulting Engineer's report show the complete system, the first six pages being plans showing track layout, and the last two profiles, showing the grades of the various lines actually constructed.

Introduction

On pages B-45, B-46 and B-46 of our Consulting Engineer's report is shown a list of 80 motor driven welders used in connection with the work. A subdivision is as follows:

40	Manual Inert Gas
4	Tractors
1	Trailer
2	Semi-Auto
7	Pipe Track
12	Automatic Cars
1	Water Cycle

Motor Investigation

The Ma[illegible] Company, the Union and the Pipe Lines, Limited and others were also the investigation will be found in that part of Chapter 2 referring to the early and final examination of the Lines and Installations.

Since the filing of the report in December of 1951, the Company [illegible] has been used for inspection in connection the whole length of the work.

Construction Safety

The construction safety system was the most important of the investigation elements. It required in all cases assembly shop of welders [illegible] and welding and was inspected by electric locomotives as well as by steam power. Pages B-47 to B-51 of the Consulting Engineer's report show the complete crews, the first six pages being shown three layers, and the last two profiles, showing the grades at the various times necessarily

In addition to transporting about 16,000,000 cubic yards of earth and rock excavation, all the raw materials for concrete work and all the major items for the construction plant, as well as for the permanent work, passed over the system. Our Consulting Engineer states the traffic on the main tracks was very heavy, the maximum density obtaining just prior to the opening of the Lundys Lane disposal area. He states that at that time the interlocking tower reported as many as one thousand train movements in twenty-four hours, being an average of one train every ninety seconds. Later, the movements frequently exceeded five hundred per day. For a general description of the various track systems in use on the work, reference should be made to our Consulting Engineer's report Chapter H on this subject. In it he deals in detail with the various parts of the system.

The equipment of the railway system consisted generally of 24 electric locomotives, 22 steam locomotives, 519 dump cars and about 50 other cars, together with cranes and other miscellaneous rolling stock. The fourteen photographs shown on pages H-74 to H-80 of our Consulting Engineer's report show the type of equipment used. WJF. H-73

While the original estimates contemplated a certain amount of equipment, requirements then estimated upon were largely increased for various reasons and equipment was purchased as the needs of the work asserted themselves. The first important order was placed on March 28th, 1917. In addition to the rolling stock there were one coal dock, one coal trestle, one locomotive shed, one car repair shop and miscellaneous WJF. H-73

storage sheds. The following is a list of the particular items of railway equipment:

Number	Description
24	Electric Locomotives
22	Steam Locomotives
319	Dump Cars
26	Flat Cars
16	Box Cars
4	Gondola Cars
3	Passenger Coaches
3	Trolley Cars
14	Push Cars
4	Hand Cars
11	Gasoline Speeders
1	Concrete Mixer
1	Snowplough
1	Wrecking Crane
7	Railway Cranes

WJF.
H-81

Machine Shop

The machine shop, or more correctly the repair shop, was located at the Whirlpool yards. In addition to its capacity for making the usual repairs to the rolling stock, the shop was also equipped with machines, forges and so forth, to enable emergency repairs to be made to practically every part of the construction plant.

WJF.
H-81

Section 19

DISPOSAL AREAS

A short description of disposal areas would appear to be properly placed in this part of the report as it was the function of the transportation equipment to convey the earth and rock excavation to the various disposal areas employed in the construction work. There were in all sixteen disposal areas, and their location is shown on the map forming page 95 of this report.

MILES FROM JUNCTION OF CANAL AND WELLAND RIVER SHOWN THUS (4)

DISPOSAL AREAS SHOWN THUS (A)

DISPOSAL AREA	REMARKS	CUB. YDS. DISPOSED EARTH	CUB. YDS. DISPOSED ROCK
(A) Navy Island	Boone Dredge	34,620	
(B) Intake Cofferdam	" "	195,087	
(C) Niagara River	Boone & Cyclone Dredges	764,935	
(D) Lidgerwood		737,062	
(E) De Witt	Cyclone & Niagara Dredges	465,674	
(F) Welland River, East of M.C.R.		39,324	
(G) Montrose		221,991	9,206
(H) Welland River West of Montrose Highway Bridge	Cyclone Dredge	694,133	
(J) Burgess'	Cyclone & Niagara Dredges	96,261	
(K) Zielski	As Planned for 1922 Dredge		
(L) Lundys Lane		2,477,231	1,317,973
(M) Cemetery		426,675	
(N) Whirlpool		1,200,417	503,924
(O) Murray's Lane		200,000	
(P) St. Davids or Main		4,967,546	1,146,616
(Q) Queenston	Power House Excavation	25,600	352,432

Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY - CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

MAP SHOWING LOCATION OF DISPOSAL AREAS

Toronto, Oct. 26th, 1922 Made by W.J.F. Checked by L.J.H.

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

95

Generally speaking wooden disposal trestles were constructed on the two main disposal areas, namely those lettered L and P on the map referred to, from which trestles the earth was dumped from the loaded trains. The spoil deposited in those disposal areas at the junction of the canal with the Welland River was conveyed to the point of delivery by means of pipe lines from the dredges employed on the sub-aqueous excavation.

The disposal area at Bowman's Gully, namely that lettered W on the map and referred to as the Whirlpool disposal is of particular interest in that Bowman's Gully was a great depression over which the canal had to cross, and the spoil deposited there now forms the foundation of the canal.

The names and designating marks of the disposal areas used for the canal excavation, together with the quantities deposited therein, are as follows:

Disposal Area	Cubic Yards Deposited	
	Earth	Rock
L Lundys Lane	2,477,231	1,517,972
M Cemetery	426,675	-
W Whirlpool	1,200,417	503,924
Q Murray's Lane	200,000	-
P St. David's or Main	4,967,546	1,146,616

The disposal area at Queenston marked Q took 25,600 cubic yards of earth and 352,432 cubic yards of rock. WJF. H-85

Section 20

CONCRETE WORK

General

The practice of the engineers of the Commission in regard to concrete construction differs from the ordinary standard practice. Our

Disposal Area	Cable Yards Depositors Yards	
1 Temple Line	3,477,181	7,121,822
2 Stanbury	823,478	-
3 Kirkgate	1,320,417	789,214
4 Murray's Lane	800,000	-
5 St. Mary's Mill	4,367,148	1,188,414

The disposal area at Greenacres covered 4 acres 23,000 cubic yards of earth and 300,000 cubic yards of rock.

Section 10

Committee Room

Inventory

The position of the negotiators of the Government is regard to

Consulting Engineer in his special report on this subject deals with the matter in detail, but briefly it may be stated that in standard practice it is the custom to predetermine the amount of cement to be used in concrete, whereas by the practice of the Commission the strength of the concrete is predetermined and the amount of the cement is apportioned accordingly. The method is based in part on the water-cement-ratio-strength-relation theory of Professor D. A. Abrams and in part on the researches of Mr. L. N. Edwards on proportioning concrete mixtures by surface area.

Four classes of concrete, called for convenience, A, B, C and D, were in use on the work. Class A was specified as being of such quality as to show a minimum compressive strength of 2,500 pounds per square inch at the age of twenty-eight days when tested in accordance with the standard methods of the Commission. Classes B, C and D were required to have minimum compressive strengths of 2,000, 1,500 and 1,000 pounds per square inch respectively under the same conditions. WJF. H-3

The testing methods of the Commission are the same as those of the American Society for Testing Materials. A complete system of inspection was carried out commencing with materials at their source of supply. Our Consulting Engineer states that the Senior Assistant Laboratory Engineer of the Commission has made an estimate which shows an actual saving of over 50,000 barrels of cement by using the principle of the Commission as compared with standard practice to obtain concrete of equal quality for the 410,000 cubic yards of concrete that had been placed up to the end of 1921. WJF. H-4 We submit hereunder a table showing the average amount of cement per cubic yard of concrete for the various classes:

Average Amount of Cement used per Cubic Yard of Concrete

Class	Barrels per Cubic Yard	Compressive Strength per Square inch
A	1.67	Minimum of 2,500 pounds at 28 days.
B	1.46	Minimum of 2,000 pounds at 28 days.
C	1.20	Minimum of 1,500 pounds at 28 days.
D	0.98	Minimum of 1,000 pounds at 28 days.

WJF. H-5

The foregoing table gives the average amount of cement actually used per cubic yard of concrete, class by class, subsequently determined from the records of the materials used therein. Being in reality a laboratory determination of the proportions according to the materials on hand so compounded as to obtain a predetermined strength, the formula cannot be stated in the terms more commonly used in concrete work. For the sake of a general comparison, it may be said that Class A corresponds approximately to the common formula of one volume of cement, one and one-half volumes of sand, and three volumes of crushed aggregate. Similarly, Class B approximates one, two, and four; Class C, one, two and one-half, and five; and Class D, one, three and six.

Concrete Work

All of the masonry in the permanent work is of concrete or reinforced concrete, and is composed of Portland cement and water with an aggregate of sand and crushed rock.

Concreting of the canal lining was commenced in November, 1920, and the bulk of it was completed by the middle of December, 1921. During

the winter seasons, when necessary, calcium chloride was used in the concrete of the canal lining to accelerate the hardening process and so enable the canal lining plants to proceed rapidly. It is stated that a very noticeable increase in the early strength of the concrete was obtained by its use, making it possible to strip the forms in as short a space of time as twelve hours even in freezing weather. WJF. H-6

Quality of Concrete

The concrete throughout the work is of excellent quality and the alignment is good. The surface is dense and its texture is uniformly even.

Cement

A total of 506,125 barrels of cement was used on the Development up to December 31st, 1921. The cement was obtained from five different mills, a complete list of which may be found on page H-8 of our Consulting Engineer's report together with the price paid per barrel and the quantity ordered from each. This list includes all the orders for the cement used by the Commission during this period and is not confined solely to the Queenston-Chippawa Power Development.

Sand

The sand was obtained from several different sources all of which are described in detail in our Consulting Engineer's report. Approximately 235,000 cubic yards of sand were purchased. One half of this was obtained from a pit accessible to the service tracks of the work, and the balance was brought from Lake Ontario. WJF. H-9

The sand was purchased at a cost of $1.50 per cubic yard delivered, for the pit sand, and $1.65 per cubic yard delivered, for the lake sand.

Crushed Rock

The crushed rock was a dolomitic limestone from the canal excavation, selected as required from the shovel output, and passed through a specially built crusher plant and placed in stock piles to be drawn upon as required. The grading of the crushed rock was practically uniform between 1/4 and 2-1/2 inches. It contained an average of 8 per cent. of dust and crusher screening, and was reasonably free from flat and elongated pieces.

Of the total output of the crusher plant only about one-third up to the end of 1921 was used for concrete. The balance is now on hand or has been sold for ballast, highways and other purposes. WJF. H-11

Mixer Plants

The concrete for the work was made in twenty-one separate plants situated along 7-1/2 miles of the Development. The concrete mixers were of the standard type being generally one-yard machines operated singly or in pairs and driven by electric motors in all cases. WJF. H-13

Pouring Methods

The customary methods of handling the concrete by means of towers, chutes and hoppers were used in all of the ordinary circumstances. For the main portion of the work, namely, the canal lining, a special construction plant was adopted, which is discussed in the following paragraphs.

Canal Lining

The canal is lined throughout its length in the rock section a distance of about seven and one-quarter miles.

It was necessary to arrange the concrete schedule so as to complete the whole work immediately after the shovels had finished the excavation. The schedule was carried out so that the concreting was finished eighteen days after the excavation was completed, and the water was admitted into the canal six days later, that is on December 24th, 1921.

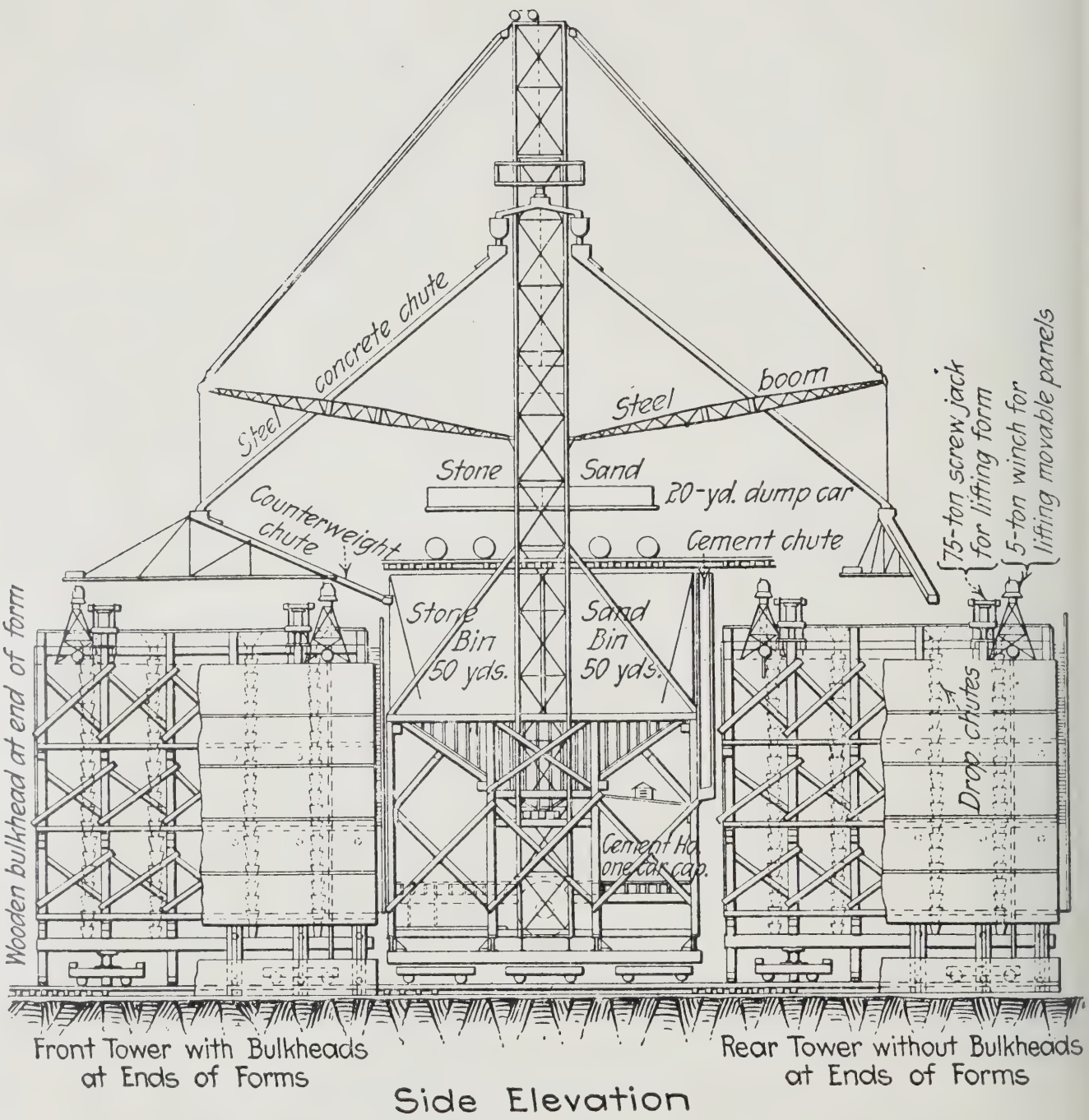
To take care of the lining in the manner and time referred to above, nine lining plants were erected and used on the work, while later a half-plant was assembled from the two plants first dismantled. The engineers of the Commission state that after an unsuccessful attempt to procure a satisfactory type of plant from specialists in this line of work, they designed the present units which were largely manufactured and entirely assembled in their own plant at Niagara Falls. A complete description of these plants is given in our Consulting Engineer's report, but for convenience we include herewith page 102 which is a working drawing of one of the units referred to. We also include as page 103 a photograph showing the finished canal lining and lining plant in actual operation. An excellent idea of the finished work may also be obtained by referring to page 104. From this photograph the excellent nature of the concrete and its accuracy of alignment may be obtained.

Canal Lining

The canal is lined throughout its length in the work, making a thickness of [illegible] inch [illegible] slab.

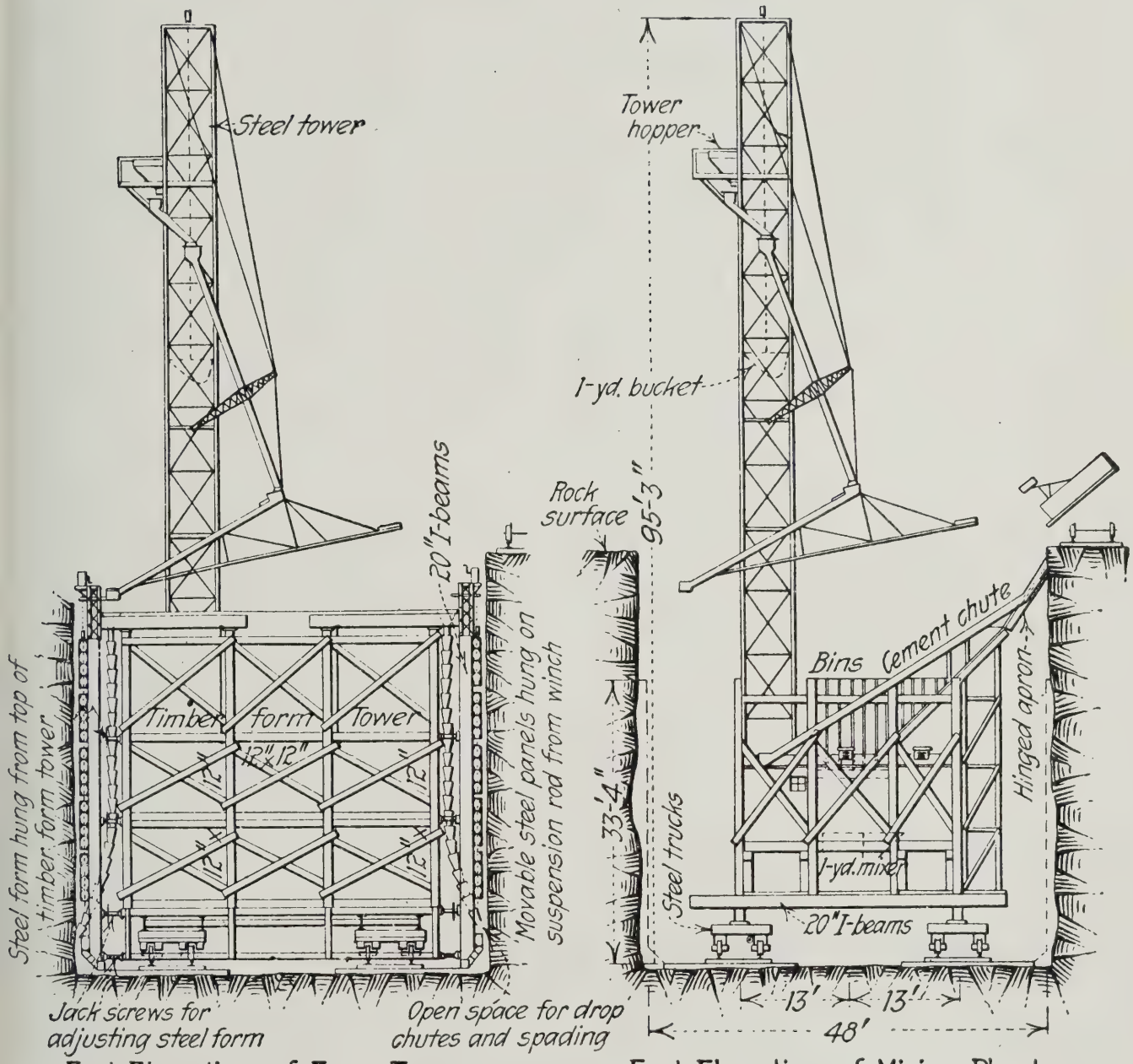
It was necessary to [illegible] the concrete [illegible] so as to complete the work [illegible] after the canals had finished the excavation. The [illegible] was carried out so that the lining was finished eighteen days after the excavation was completed, and the water was admitted into the canal six days later, that is on December [illegible], 1931.

To take care of the lining in the manner and time referred to above, nine lining plants were erected and used on the work, while later a half-plant was assembled from the [illegible]. The designers of the [illegible] to produce a satisfactory type of plant [illegible] when they designed the present units [illegible] entirely assembled on their own [illegible]. A complete description of these plants is given in our Consulting Engineer's report, but for convenience we [illegible] on page [illegible] a drawing of one of the units referred to. We also include on page 10[illegible] a photograph showing the finished canal lining and lining plant in actual operation. An excellent idea of the [illegible] may be obtained by referring to page [illegible]. From this photograph [illegible] the concrete and its accuracy of alignment may be obtained.



Side Elevation

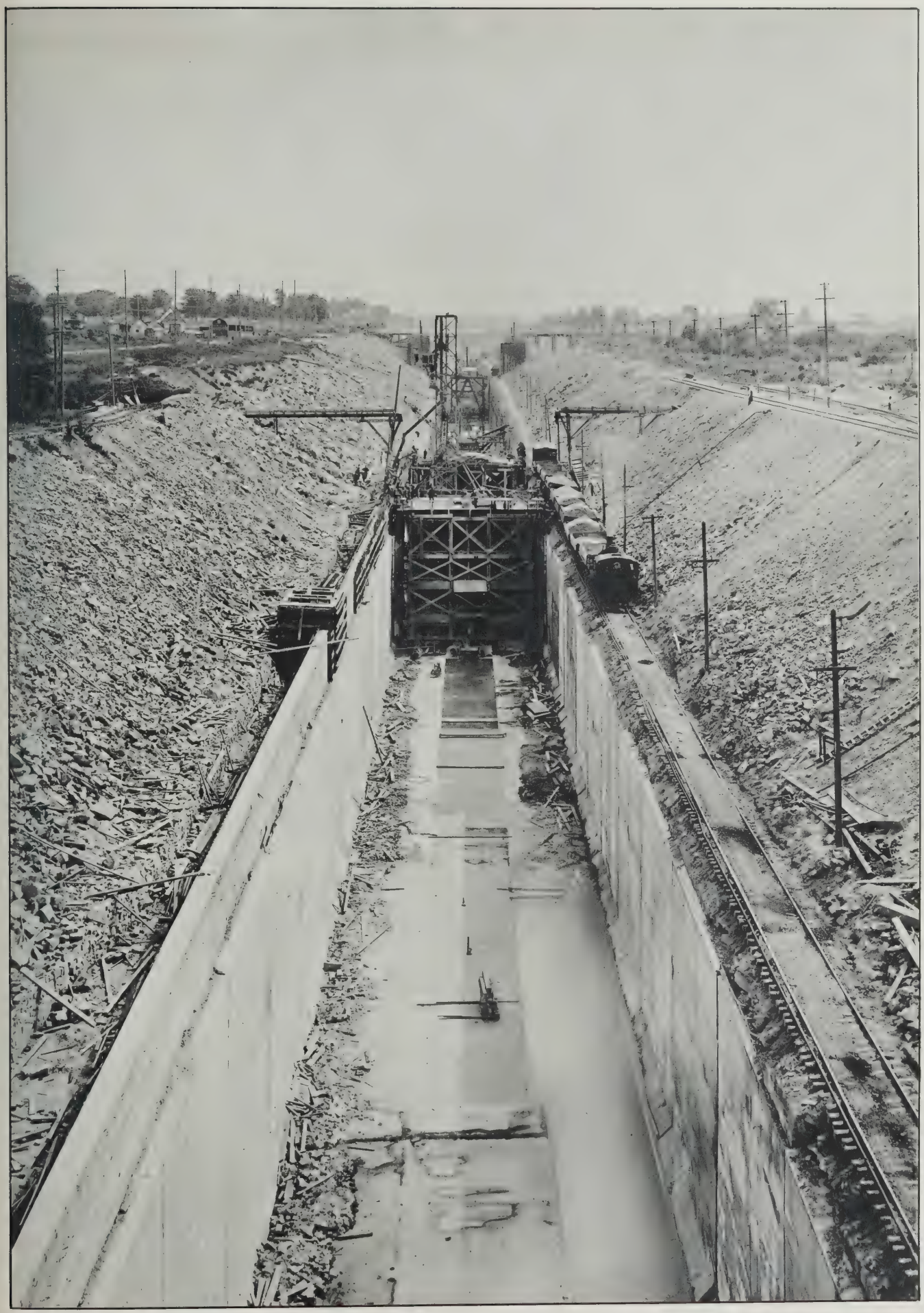
MIXING PLANT AND FORMS FOR PLACING LINING ON POWER



End Elevation of Form Towers

End Elevation of Mixing Plant

RECTANGULAR SECTION OF QUEENSTON-CHIPPAWA CANAL



Whirlpool Section

The lining plants were not used for placing the concrete in the Whirlpool section of the canal. As will have been noted in our description of the work this section of the canal was especially designed to meet the conditions encountered in filling Bowman's Gully to form a foundation for this section of the Development.

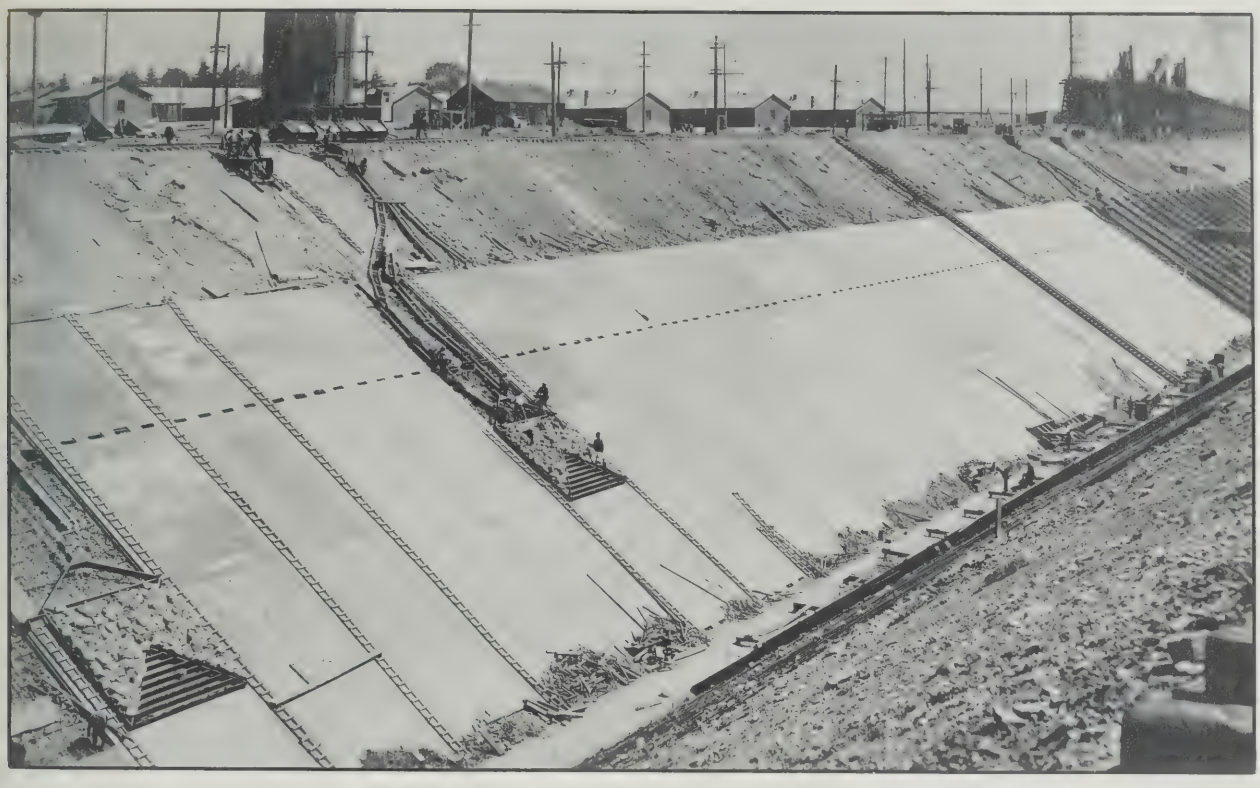
There is nothing unusual, however, in the construction plant used in connection with this part of the work, as the concrete was delivered to the work from the service railways on the banks. We include herewith as page 106 typical photographs showing work in progress on this part of the canal and as page 107 photographs which illustrate most clearly the intricate form work required in the transition sections of the canal which occurred at this point. It is again of importance to note the excellent nature of the concrete shown in these photographs.

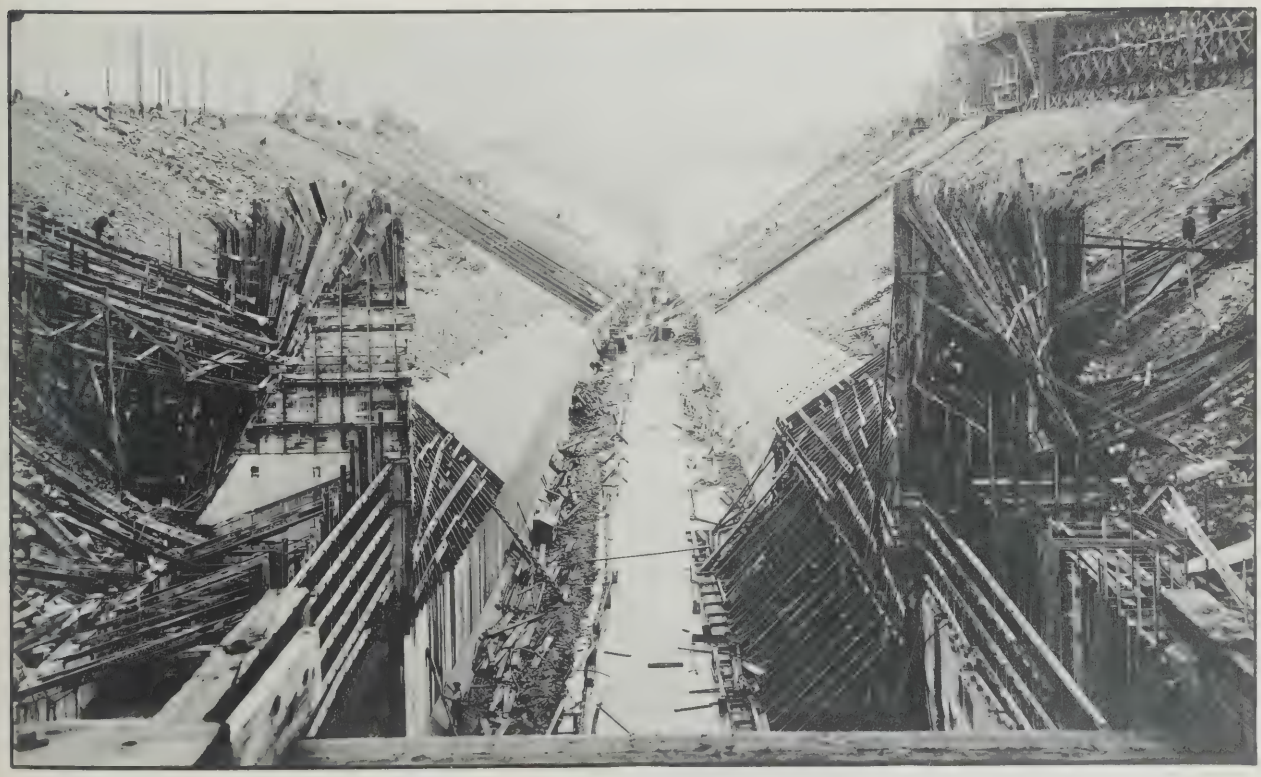
Quantities

The total quantity of concrete and reinforced concrete in the Development as at March 31st, 1922, was 427,164 cubic yards made up as follows:

Canal	304,299	cubic yards
Forebay	6,440	cubic yards
Screen House and related work	32,492	cubic yards
Penstocks	9,026	cubic yards
Power House	50,072	cubic yards
Bridges	24,836	cubic yards
T o t a l	427,164	cubic yards

WJF.
H-36





Section 21

CONTRACT WORK

As shown in Section 15 certain parts of the work were conducted on a contract basis. The following paragraphs deal briefly with these particular items according to the elements of the Development in connection with which contracts were made.

The Intake

As previously stated a contract was entered into with Messrs. Tomlinson, Macaw and McDonald of Winnipeg, on May 5th, 1922, which contract may be said to embrace the construction of the intake and the ship channel. A perusal of the contract terms shows that the interests of the Commission were well protected and that the unit prices under which the contractor executed the work were quite as low as could be expected. We submit hereunder a table given by Mr. Francis on page C-6 of his report, showing the nature of the work, its extent and the unit prices under which the contract was let:

Description of Work	Quantity	Units	Price per Unit
Earth Excavation	80,000	cubic yards	$0.94
Rock Excavation	25,000	cubic yards	2.65
Earth Fill	81,000	cubic yards	.20
Rip-rap	15,000	square yards	1.00
Concrete, cement being supplied by H. E. P. C.	32,000	cubic yards	5.25
Placing Iron and Steel supplied by H. E. P. C.	140,000	pounds	.03
Reinforcing Steel	960,000	pounds	.03½
Timber in Cribs	406	thousand feet board measure	70.00
Iron fastenings in Cribs	15,000	pounds	.04

Section II

CONTRACT WORK

In order to provide a central point for the local labor organizations to work from, a contract was entered into with Messrs. Thomas and Robinson of Chatham, on the 15th July, 1914, whereby the contractors undertook to carry out the excavation of the intake and the ship channel. A perusal of the contract herein shows that the interests of the Commission were well protected and that the work proceeded under the supervision of the Commission's engineers. The work was quite as low as could be expected. We submit herewith a table given by Mr. Symonds on page 6-6 of his report, showing the history of the work, its extent and the unit prices under which the contract was let:

Description of Work	Quantity	Units	Prices per Unit
Earth Excavation	80,000	cubic yards	30.3¢
Rock Excavation	80,000	cubic yards	2.6$
Earth Fill	11,000	cubic yards	.2$
Rip-rap	24,000	square yards	1.4$
Concrete, cement being supplied by H. B. P.	20,000	cubic yards	8.1$
Piling Iron and Steel supplied by H. B. P.	120,000	pounds	.4$
Structural Steel	260,000	pounds	.05$
Timber in Cribs	300	thousand feet board measure	20.00
Iron fastenings in cribs	12,000	pounds	.4$

Description of Work	Quantity	Units	Price per Unit
Removal of Sheet Piling and Lumber in Temporary Dam (Timber, 464 thousand feet board measure; Iron Fastenings, 125,000 pounds; Steel Sheet Piling, 187,100 lineal feet)	Whole	Whole	$29,257.50

The total contract at the estimated quantities amounts to $436,727.50.

It is to be noted that the contract does not include the gathering tubes contemplated in the ultimate design. In the agreement, the contractor undertook to complete the work on or before December 31st, 1922, the contractor furnishing all plant, labour and material with the exception of cement. The cement for the work was delivered to the contractor by the Commission at the nearest railway siding.

W.J.P.
G-5

The Welland River

By contract made with Messrs. E. C. Leahy & Co., Limited, dated May 22nd, 1922, the contractor undertakes to remove not less than 800,000 cubic yards of material by the 31st day of December, 1922. The unit prices submitted by the contractor include the furnishing of all labour and materials excepting certain specified items to be supplied by the Commission. In addition the contractor is required to provide all plant and apparatus required. The agreement made with the contractor appears to adequately protect the interests of the Commission and the unit prices under which the work is being conducted appear to be fair and reasonable.

The unit price is placed on a sliding scale varying from 33¢ per cubic yard to 40¢ per cubic yard varying inversely according to the amount of excavation done. WJF. 6-11

The Canal

No work was done on the canal under private contract other than the supplying of ordinary construction materials and specially built parts such as the control gate near Montrose. Tenders for the canal work were invited in December, 1916, but the work was not let on a contract basis, and, since a discussion of this matter more naturally comes in another part of this report, we will not deal with it further at this point.

The Screen House, Power House and Tailrace

In accordance with standard practice, the Commission placed contracts with specialists for the manufacture and erection of the more important elements of the Development, such as structural steel work, turbines, generators, cranes and so forth. With the exception of the bridge superstructures which are dealt with separately, the following are the principal engineering contracts entered into:

Dominion Bridge Company, Limited, Montreal, Quebec.

March 29th, 1921	-	Superstructure for Control Gate, erected	$6,000.00

Canadian Bridge Company, Walkerville, Ontario.

May 16th, 1920	-	All structural steel for Queenston Generating Station, erected, per ton of 2,000 pounds	135.00

Turnbull Elevator Company, Toronto, Ontario.

May 26th, 1921 - Three electric Elevators, installed $36,700.00
(Sales Tax Extra)

McGregor & McIntyre, Limited, Toronto, Ontario.

February 26th, 1921 - Structural steel for Screen House, erected 39,606.00
(Sales Tax Extra)

Lerner-Johnson Valve & Engineering Co., Philadelphia, Pa.

May 13th, 1920 - Five Johnson valves, 14 ft., erected 239,710.00

January 11th, 1921 - Two Johnson Valves, 42" inlet, erected 25,800.00

Wellman-Seaver-Morgan Co., Cleveland, Ohio.

June 30th, 1919 - Two Turbines, 52,600 horse-power each, installed 243,845.00
(more or less)

Price to be adjusted according to variation in price of metals.

October 7th, 1921 - Spare parts for Turbine, delivered ... 4,400.00

The William Cramp & Son, Ship and Engine Building Co., Philadelphia, Pa.

July 8th, 1920 - Three Turbines, 55,000 horse-power each, installed ... not to exceed 765,000.00

Price varies with duty, freight and exchange.

Canadian Allis-Chalmers, Limited, Toronto, Ontario.

February 4th, 1921 - Two Service Turbines with governors, installed 65,000.00

Canadian Westinghouse Company, Hamilton, Ontario.

December 3rd, 1920 - Two 2,200 kv.a.Service Generators, installed 90,290.00

Terms to be adjusted according
to variation in price of
metals.

The Canadian General Electric Company, Toronto, Ontario.

February 26th, 1920 -	Two 45,000 kv.a.Generators, installed	$1,000,000.00

Canadian Westinghouse Company, Hamilton, Ontario.

February 11th, 1919 -	Two 45,000 kv.a.Generators, installed	913,550.00
February 26th, 1920 -	One 45,000 kv.a.Generator, installed	455,500.00

Dominion Bridge Company, Limited, Montreal, Quebec.

March 31st, 1920 -	Two 150-ton Electric Cranes, installed	93,160.00	WJP.
November 1st, 1920 -	Five steel Penstocks, erected	620,122.00	C-35

Since the date that our Consulting Engineer prepared this information we are advised that additional contracts have been let in connection with Units Nos. 6, 7 and 8.

All contracts have been proceeded with in due course and have been substantially completed with the exception of the instalment of Unit No. 6, which it is expected will be in operation some time during December, 1923, or January, 1924.

Section 22

TEMPORARY BUILDINGS

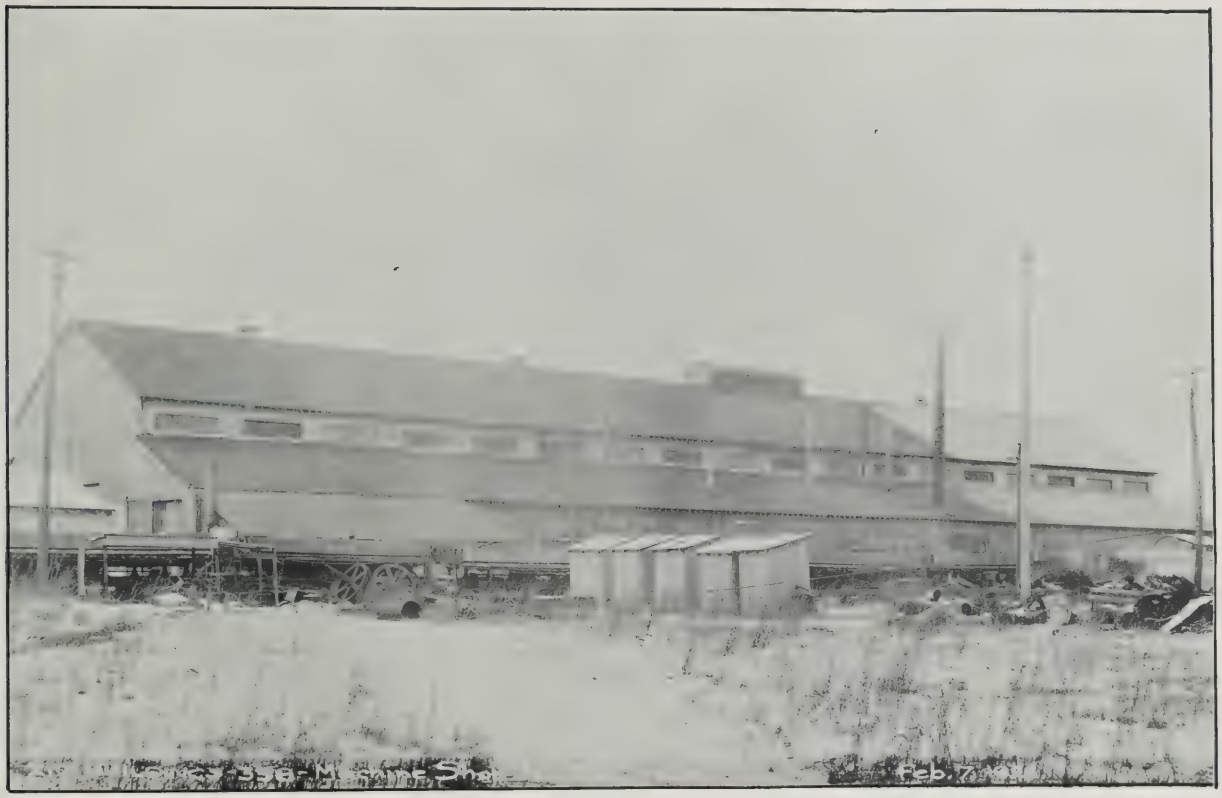
This subject is dealt with fully in our Consulting Engineer's report entitled "Chapter J - Quantities, Temporary Buildings and Commissariat for Construction". In that report Mr. Francis gives typical illustrations of the various types of buildings and on pages J-77 to J-87 he gives a complete list of the buildings, numbering 507 in all. Each table indicates the use to which the building was put, the nature of its construction, its size and cost.

In carrying out construction work on the Development, the service buildings used in connection therewith formed an important element. These buildings consisted of houses, sheds and other structures, situated on the several parcels of right-of-way, and of new structures specially built for the particular purpose in hand.

Generally speaking, the buildings were used for such purposes as lodging and boarding places for workmen, engineering and administration quarters, plant housing and repair shops, storage, watchmen's shelters and so forth. All of the buildings referred to in this discussion are concerned only with the question of construction and do not directly form a permanent part of the Development. The general nature of the buildings constructed may be best illustrated by referring to certain photographs included herewith. On page 114 we include a photograph which shows a typical large boarding house used for skilled labour. It is to be noted that the building is of wooden construction with standard T. & G. siding on the exterior walls, the roof consisting of corrugated iron. The interior walls of the building were boarded. On page 115 will be seen two photographs showing different views of the main office building for the works. It is to be noted that this building is of a better type of construction from the standpoint of fire hazard, for while the construction is of frame, the exterior and interior walls have been gunited.

From the photograph given on page 116 an excellent idea of the nature and magnitude of the repair shop may be obtained. This building was completely outfitted with the best type of machinery and appliances obtainable, necessary for the making of repairs or the manufacture of various


210-BUILDINGS. 4-31. Front of No. 100.
Feb. 9. 1922.


Feb. 7, 1922


Feb. 8. 1922

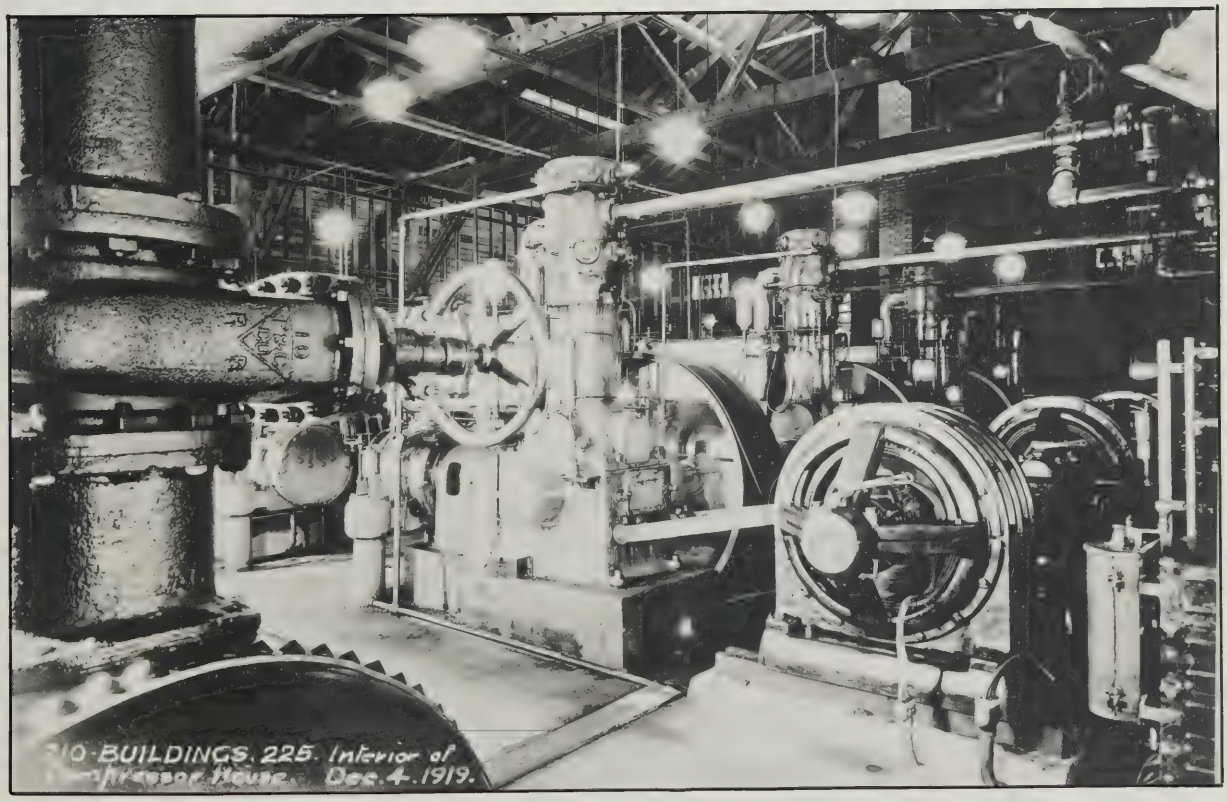
pieces of equipment employed on the construction work.

On page 118 are given two photographs, the one at the top of the page showing the installation of equipment necessary in the sub-station at the Whirlpool. The lower photograph shows the interior of the compressor station also located at the Whirlpool, which supplied the compressed air for the drilling operations in connection with the rock excavation.

As before stated our Consulting Engineer's report shows that there were 507 temporary construction buildings in connection with the work. These varied in size from an ordinary temporary shelter, housing some piece of equipment, erected at a cost of a few dollars, to buildings costing $20,000, $30,000, $40,000 and $50,000. Many of the buildings were entirely unheated, others were heated by stoves, some by furnaces and others were equipped with a steam heating system. As noted, some of the buildings were all of wooden construction supported on cedar posts, others had their exteriors gunited and interiors plastered, some supported on concrete foundation walls and others on concrete pillars.

The total cost of the temporary buildings as shown by the records and as confirmed to us by the engineers of the Commission, within reasonable limits, was $2,214,054.58, as at March 31st, 1922. This figure includes the original construction cost of the buildings as given in the tables included in our Consulting Engineer's report together with all their equipment, operation and maintenance costs, as well as a due proportion of the local and general overhead charges. It is stated that


210-Buildings-83. Interior Railway Sub Sta. Mar. 7.18.


210-BUILDINGS. 225. Interior of
Dec. 4. 1919.

nearly the whole of this amount has been absorbed in the general construction account of the Queenston-Chippawa Development, the only item remaining on the books as a direct charge against buildings, being the figure of $150,761.09 which the engineers of the Commission have fixed as the salvage value of the temporary buildings. WJF J-98

In dealing with the disposition and salvage of the buildings, our Consulting Engineer states as follows:

"It is difficult if not impossible to place an exact salvage value on the temporary buildings. The acquired buildings on comparatively favourable sites undoubtedly retain much if not all of their original domestic value, as the proximity of the canal is not necessarily a detriment to the building itself. The newly constructed temporary buildings have only a transitory value. Owing to their size and type they are not suited, within economic limits, for anything but the purpose for which they were constructed. If wrecked, the salvage value would not be very great. It is possible that in occasional instances some return might be obtained. On the whole, however, I am disposed to the opinion that of the total cost of the temporary buildings at least two million dollars will have to be charged up against the construction cost of the Queenston-Chippawa Power Development.

"It is conceivable that if a material increase in the Queenston-Chippawa Power Development were decided upon following along the present general lines, the temporary buildings might be again called upon to perform their original function in many cases.

"Meanwhile most of the important temporary buildings are out of commission and are closed with barriers, while those in service are housing the present working plant and continuing to function as before." WJF J-98